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## IMPLEMENTATION OF A PHOTOVOLTAIC SYSTEM FOR CHARGING MOBILE DEVICES AND VIDEO SURVEILLANCE IN THE COMMUNITY OF CUICUNO, LATACUNGA, ECUADOR

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**Abstract:** This paper explores the implementation of a photovoltaic system in the Cuicuno market, Latacunga Province, Ecuador, with the aim of improving security through video surveillance cameras and providing power for charging devices. The project addresses the challenge of electrifying rural areas in Ecuador, where only 1% of energy comes from renewable sources and 6% of the rural population still lacks electricity, underlining the importance of renewable energies such as solar. The methodology includes the selection of components such as solar panels, charge regulators, batteries and converters, followed by testing and monitoring to ensure the efficiency of the system, designed to power two cameras with a total power of 120W. The results show that the system installed on the roof of the market not only provides continuous power and reduces carbon dioxide emissions, but also generates energy savings and has a positive environmental impact. Training the local community in the use of clean energy encourages the adoption of sustainable technologies. As a result, the project improves energy security and autonomy in Cuicuno and serves as a model for other rural communities in Ecuador, supporting sustainable development through renewable energy. This project not only responds to immediate local needs, but also contributes to long-term sustainability goals.

**Keywords:** Photovoltaic energy, Renewable energy, Sustainable development, Safety devices, Clean technologies.

## INTRODUCTION

Humans need energy in their activities and in their daily lives, therefore, they need a specific energy industry structure to obtain the necessary services. Rural electrification through the use of renewable energy has become increasingly important in recent decades, especially in developing countries in Latin America such as Ecuador. (Fao, 2019) Renewable energy is the energy obtained from inexhaustible natural resources, some of which are due to the fact that they contain a lot of energy and others because they can be regenerated naturally. They are considered clean or green in principle because they pollute little and do not emit enough gases to produce greenhouse effects. (Llano, 2020). According to natural methods, renewable energies form the basis of three basic pillars of sustainable development: social, economic and environmental quality. The use of renewable energies requires sustainable development: considering the economic level (economic growth), the social level (social progress) and the environmental dimension (environmental protection and reasonable use of resources; Álvarez, 2019)

Nowadays, the production of electrical energy depends largely on available fossil resources and the possibility of access to their sources. The use of this type of energy has caused a great negative impact on the environment with respect to carbon dioxide emissions in the atmosphere (Perpiñán, 2013).

In Ecuador, according to MEM data, 92% of the country's energy generation currently comes from hydroelectric plants, 7% from thermal plants and 1% from non-conventional energy sources, including: photovoltaic, wind energy, biomass energy, biogas, geothermal energy, among which (Ministry of Mines and Energy, 2020). According to the World Bank, approximately 6% of the rural population still does not have access to electricity 6. Given

this situation, decentralized renewable energy has become a viable and sustainable solution that can bring energy to remote communities and promote local development (World Bank, 2022). Access to electricity is of vital importance for the development of humanity, and has allowed the development of complete transformation, storage and distribution systems. For several decades, the use of fossil fuels has allowed the development of populations, who have depended on this type of fuel for energy generation.

That is why the use of alternative energies as electricity production measures today is a topic that several researchers are implementing in various sectors, such as industry, construction, among others. An alternative energy is photovoltaic energy, which offers alternatives to reduce electricity consumption, its use has ecological advantages to produce clean, inexhaustible, economical and long-lasting energy. This energy uses a photovoltaic system, which is obtained by converting sunlight into electricity, through the use of solar panels (Calderón, 2020). This project focuses on the implementation of a photovoltaic system in the community of Cuicuno, located in the province of Cotopaxi, with the aim of powering a video surveillance system and providing energy for charging devices. The adoption of this technology will not only contribute to the improvement in community security by providing reliable energy for surveillance cameras, but will also encourage the use of renewable energy in a region with significant challenges in energy access and environmental sustainability.

## **MATERIALS AND METHODS**

We accurately determined all the elements of the photovoltaic system to guarantee its good performance and ensure that it met the requirements of the installed load in the Cuicuno community market. We performed the system's operational tests under all the conditions to which it would be subjected, ensuring that the entire kit was fully operational. In addition, we established a regular monitoring plan to confirm that the system was working correctly and scheduled periodic maintenance to ensure the efficiency and durability of the equipment.

## **COMPONENTS**

The essential components for the installation of solar panels are: The solar panel: it is a really convenient alternative source of renewable energy, it becomes a solution to promote energy in a home. Charge regulator: it is the link between the union of the solar panels and the other components of the installation, it is responsible for protecting the previously overloaded accumulators, thus providing the continuous voltage output for the installation. The battery is essential because it sometimes accumulates enough energy in case of periods without sunlight. The DC-DC Inverter: it allows converting photovoltaic energy into alternating energy; later this energy is used through the USB ports to recharge devices. In addition to the elements used for the execution of the photovoltaic system, cables are required for the respective installation of the photovoltaic system, galvanized pipe to place the cables and current protections to eliminate failures in weather situations that may arise.

To meet the objectives of the research on what impact the integration of renewable energies will have on the Ecuadorian electrical grid, its economic and environmental benefits, a quantitative method and a qualitative

method were used, as well as a bibliographic review, a selection of representative research.

## PHOTOVOLTAIC SYSTEM

Currently, non-conventional renewable energies such as photovoltaic energy are being used through solar panels as an alternative energy supply. Photovoltaic energy is based on the photoelectric effect, which occurs when solar radiation hits semiconductor materials, generating a flow of electrons inside the material of the panels, obtaining a voltage, which by placing metal contacts can extract the electrical energy that allows charging the devices.

The methodology used to develop the "Photovoltaic Energy" project consisted of 5 phases for the execution of the project: Phase 1. Determination of the required solution: In this phase, the collection of the different data of the most relevant aspects of the project in the parish of Cuicuno was carried out, with the use of surveys it was possible to determine which of the energy is the most feasible for the implementation. Phase 2. Prototype planning: In this phase, the characteristics and parameters that the system must meet to guarantee the satisfaction of the energy needs were defined, that is, to generate energy for the security cameras and charge the devices. Phase 3. Prototype execution: In this stage, both the electrical and structural design of the photovoltaic energy equipment that was placed in the community of Cuicuno was carried out. Phase 4. Results and costs: In this phase, the operational tests of the prototype of the photovoltaic system were carried out, in addition, in this stage, the financial analysis was carried out to know the final costs of the production of the prototype. Phase 5. Analysis and proposals for improvement:

In this final stage of the process, once the results were obtained after the respective tests of the photovoltaic system operating

process, alternatives were analyzed for the implementation of changes in the system in order to increase performance.

## PHASES OF CONSTRUCTION OF THE PHOTOVOLTAIC SYSTEM

Step 1: As a preliminary step to design and size the photovoltaic solar panel for the project, we considered the average solar irradiation at the location where our solar project was installed. We used the information available at INAMHI (National Institute of Meteorology and Hydrology) through the UV index data viewer. We were able to obtain the average irradiation throughout the year in the Cuicuno neighborhood, in the Cotopaxi Province, which was 4.42 kWh/m<sup>2</sup>.

Step 2 for sizing the panel was to know the load of the various safety devices, which ranged between 3.6 and 3.7 volts. Step 2: To select the solar accumulator, we determined the voltage and capacity in ampere-hours, as well as the maximum current generated by the accumulator, which turned out to be 12 volts. Step 3: The parameter for selecting the charge regulator was the current capacity in amperes. For the 80W panel, we established the need for a charge regulator of at least 5 amps. Fourth step: For the dimensions of the DC-DC converter, we considered the voltage range of the battery as input and an output voltage of 5 volts, which allowed the equipment to supply a nominal current suitable for charging the devices. Fifth step: We designed the structure consisting of the lockers and the respective support for the panel, which was metallic and also glass. We considered that the panels must have an angle of inclination appropriate to their geographical location, which we determined at 7.3°, ideal for the support structure to correctly adjust the angle of inclination.

In addition, the lockers we installed serve to place the devices during their respective charge. Sixth step: We carried out the wiring following the Ecuadorian Technical Regulations, in addition to implementing the necessary protections to ensure the correct operation and safe use of the photovoltaic energy destined to charge the devices in the Cuicuno neighborhood.

By carrying out the analysis with the different search criteria that come from articles, reports, scientific journals, governmental and non-governmental websites, with verifiable statistical data, relevant information was selected that was used in carrying out the research in order to meet the objectives of the article.

## RESULT

**Opening Meeting:** An opening meeting was held with representatives of the Vivandera Association and workers from the Cuicuno central market, where the project to be executed was formally presented and explained, in this case the implementation of photovoltaic energy for the use of security cameras and charging of various devices.

The installation of the photovoltaic energy system in the central market of the Cuicuno neighborhood for the operation of two video surveillance cameras, the model applies appropriately to the installation of the system to be mounted, consisting of a solar panel consisting of 120w power, a solar controller or 20A charger, 2 sealed batteries of 60 AH each, the same ones that are connected to the security cameras (external and internal). The solar panel was cast on the top of the roof, to obtain more direct sunlight in order to provide a security system for the market, guaranteeing 24-hour monitoring on fair days (Sunday) safeguarding the safety of users and visitors of the site.

Based on the results, it was verified that the photovoltaic system generates the necessary electrical energy, obtaining a result of 120W and that it correctly powers the 2 security cameras since the panels deliver a current of 20 Amps under maximum radiation conditions of which they are destined to charge the accumulation system (60 AH batteries) which will be fully charged in 7 hours. This way, autonomous electrical power for the surveillance system is guaranteed, taking into account that they are 2 Imou 12v Ptz type cameras, which offer live monitoring of 2MP resolution with a 3.6mm lens, 1080P Full HD live, monitoring and Pan functions of 0 ~ 355 ° and tilt 0 ~ 90 °, it also supports four night vision modes for daytime clarity even in total darkness, since the 1080P sensor and advanced infrared algorithms provide clear video both day and night. Cutting-edge H.265 compression reduces network bandwidth and storage usage by 50% with the same video quality.

The impact of the project based on the implementation of the energy supply system can be highlighted as a technological impact with the use of renewable energy, encouraging future students to take the initiative to carry out these projects since it is innovative and to verify the efficiency of the use of this resource, in order to not depend on non-renewable, polluting energies that are used with greater magnitude today, giving rise to a positive environmental impact, since the operating principle or the clean origin of the energy produced with solar panels can contribute to the care of the environment; In addition (Erazo, 2017), in their research entitled design and implementation of a clean energy system, they mention that implementing these types of projects based on the use of solar panels also has an economic impact, since it causes a high economic investment depending on the load that they want to supply, but in the long term the investment will generate savings.



Training: The respective training sessions were held for representatives of the Vivanderas market workers association, where topics such as the operation of the solar panel, advantages and disadvantages of implementing renewable energy, correct measurements of how to use the implemented switches were discussed. For the correct explanation in the training sessions, brochures and the solar panel itself were used so that people could better understand the handling and operation.

Project Delivery Regarding this point, an event was held in which the Vivanderas Association, teachers representing the university and the work groups that contributed with linking projects in the association participated.

The project "Use of Photovoltaic Energy in Security Devices in Cuicuno, Cotopaxi Province, Ecuador" required a total investment of \$720.50 for its implementation. This budget covered all essential aspects of the project, including the acquisition of solar panels, accumulators, charge regulators, DC-DC converters, as well as the support structure and necessary wiring. The allocation of these financial resources made it possible to guarantee the correct installation and operation of the photovoltaic system, thus ensuring the supply of clean energy for the security devices in the community of Cuicuno.

## DISCUSSION

The Constitution of the Republic (Republic of Ecuador, 2008), among its articles, considers the promotion and use of renewable energies, which are transcribed below: "Article 15.- The State promotes in the public and private sector, the use of environmentally clean technologies and non-polluting and low-impact alternative energies. Energy sovereignty is not achieved to the detriment of food sovereignty, nor does it affect the right to water."

Within the framework of the project on the use of photovoltaic energy in security devices in Cuicuno, this article highlights the importance of aligning the project with national policies that promote the use of clean energy. The implementation of photovoltaic energy in this project complies with constitutional regulations.

Photovoltaic solar energy is the radiant energy of the sun that is transformed into electrical energy through the use of photovoltaic cells; this method is classified as a form of direct use of solar energy. The photovoltaic effect generates an electromotive force in a semiconductor device, due to the absorption of electromagnetic radiation when connected to an electrical circuit. (Bravo, 2015)

The application of photovoltaic energy in rural areas is important because it provides an accessible and sustainable source of electricity in areas that lack electrical infrastructure. By not depending on extensive electrical networks, photovoltaic systems can be installed independently in these regions.

Among the advantages of using photovoltaic energy as a source of generation, it is highlighted that it is not polluting and comes from an inexhaustible source such as the sun and is an excellent system for those areas where there are no installed electrical networks, these can amortize their cost with their benefits, since maintenance is little and its useful life is long. (Pinzón, 2016)

Its cost is amortized over time through low operating and maintenance costs. Photovoltaic energy does not require additional fuels nor does it have variable costs associated with its operation, making it an economical option in the long term.

## CONCLUSION

The adoption of clean energy contributes significantly to the reduction of greenhouse gas emissions, improving air quality and public health. The objective was to implement a video surveillance system in the Cuicuno sector and it will take advantage of photovoltaic energy as a power source. The appropriate components for the system were selected, such as solar panels, batteries, regulators, cameras and recorders. The system was installed at two strategic points, the first outside and then inside the market, where its operation is monitored and its performance is evaluated.

The implementation of the video surveillance system was carried out, which will contribute positively to maintaining and safeguarding the safety of the people who live in the Cuicuno neighborhood and at the same time the visitors who come to the place. The results obtained showed that the video surveillance system with photovoltaic energy is technically and economically viable, since it meets the security and image quality requirements, and generates savings in electrical energy and a reduction in CO<sub>2</sub> emissions. In addition, the system contributes to the promotion of renewable energies and environmental awareness.

The implementation of the renewable photovoltaic energy system represents a valuable alternative to improve the consumption of electric energy. By adopting this sustainable and environmentally friendly solution, it contributes significantly to reducing the dependence on non-renewable energy sources and decreasing the emission of greenhouse gases. In addition, the use of photovoltaic energy not only provides environmental benefits, but also leads to long-term economic savings by reducing operating costs and maintaining greater energy autonomy within the Cuicuno market.

Training the Vivanderas Association of the Cuicuno community on clean and sustainable energy issues represented a significant step towards promoting environmentally friendly practices in their community. By providing them with flexible, accessible and easy-to-use knowledge, these women are empowered to adopt sustainable technologies and strategies in their daily activities, generating a positive impact on both their businesses and the local environment. This initiative will not only strengthen energy efficiency, but will also contribute to the well-being of the community at large, laying the foundations for a more environmentally conscious and respectful future.

Encouraging citizen participation towards the use of photovoltaic energy through the Vivanderas Association of the Cuicuno community translates into a series of significant benefits for society, the economy and the environment. By promoting the use of solar energy, the community will not only reduce its dependence on conventional and expensive energy sources, but will also actively contribute to the preservation of the environment, by decreasing greenhouse gas emissions and mitigating climate change. In addition, the use of photovoltaic energy could generate long-term economic savings for families and the community, freeing up resources to invest in other crucial aspects of local development. Likewise, this initiative can empower citizens and strengthen their sense of community, by participating in joint projects that benefit everyone. Ultimately, the promotion of photovoltaic energy through the Vivanderas Association not only boosts the well-being of the Cuicuno parish, but also sets an inspiring example for other communities, promoting a more sustainable and responsible future for all.

## RECOMMENDATIONS

It is recommended to perform a prior analysis of the deployment site, to correctly determine factors such as orientation since the panel takes advantage of the maximum power when the inclination angle is the same as the altitude, which is 20° and 25°. Regularly monitor the performance of the photovoltaic system, including solar panel efficiency, battery charge levels and camera functionality. Clean the solar panels periodically to remove dirt or debris that may reduce their efficiency.

By following these steps, we can successfully implement video surveillance

cameras using photovoltaic energy. It is necessary to determine exactly all the elements of the photovoltaic system for a good performance of it and for the system to meet the requirements of the installed load in the Cuicuno market.

The photovoltaic system must be tested under all the conditions to which the system will be subjected, which requires that the entire kit be in operation. Establish a regular monitoring plan to ensure that the system is working properly. Also, schedule periodic maintenance to ensure the efficiency and durability of the equipment.

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