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Photovoltaic System to Improve Energy Efficiency

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Abstract

Renewable energy sources are generation alternatives that can be used for different applications; Systems that take advantage of photovoltaic solar energy can be used to reduce energy demand during daytime hours, electrification of isolated homes, among other applications. In Ecuador there is a high potential for solar radiation, which can also be applied to project systems connected to the electricity grid or in the form of distributed generation, the objective of the research is to demonstrate the potential for solar radiation that affects the province of Manabí, specifically in the site "El Aromo" in the rural area of the city of Manta there is a land that provides the necessary conditions for the installation of a photovoltaic plant, for the development of the work the bibliographic review method was applied, the inductive deductive and synthesis analysis, the results that can be used were obtained from the installation that exists as a base of the 140 houses that consist in the field that belonged to the old project of Refinery del Pacífico.

Contents

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1 Introduction

Renewable energies are clean and almost inexhaustible resources provided by nature. Due to their indigenous nature, they help reduce dependence on fossil fuels and purchase from external supplies, reduce the risk of a poorly diversified supply and favor the development of new technologies and job creation. The energy produced by the sun can be used in different ways, as it is the most responsible for the emergence of other renewable sources (Limones-Pozos et al., 2018), these can be used with different technologies. Solar energy can be transformed into electrical or thermal energy. Rooftop photovoltaic panels are the most widely known, however, the advancement of technology has given rise to different varieties: flexible panels, low cost, in orbit around the earth, or applicable as paint on any kind of surface (Fernández et al., 2008).

Photovoltaic systems can be feasible to use anywhere in the earth's geography due to their easy location (Arafet et al., 2014), if they are used in grid-connected systems, only their proximity is needed, and that there are adequate ground conditions, Aspects that should be assessed in the feasibility analysis according to the regulations of each territory. One of the aspects that must be taken into account in an essential way when we are going to install a photovoltaic system are the studies of the extension of the electric line to be able to compare prices (Poblano Ortiz et al., 2015). In addition to the fact that for systems connected to the network, it is necessary to know at what distance the system can be connected in such a way as to reduce losses.

Regarding the generation of electricity in Ecuador, it is suggested that the country has traditionally been supplied with hydroelectric energy (renewable) combined with a percentage of energy thermal(non-renewable) from fossil fuels. Since the beginning of the last century, the populations of the mountains had small hydroelectric plants built by the municipalities, on the other hand, in the absence of the resource of water flow and height, the municipalities of the coast developed small thermal plants that, in some cases, operated only a few hours a day.

In this regard, it is important to mention that the country is rich in renewable resources. For example, insolation rates (solar radiation) are among the highest in the world, which are conducive to the installation of high-performance photovoltaic plants (Arauz et al., 2017). On the other hand, an aspect of relevance to highlight is that the sunlight that falls on the Ecuadorian territory makes photosynthesis possible, greatly encouraging the growth of plants, hence it is an ideal area for agriculture, for example, the cultivation of flowers. This is a factor with which the solar efficiency of the country is measured.

An example that has currently been carried out around the use of solar energy, according to the writing of the Líderes Magazine (2020) is concentrated in a study carried out by the businessman Hugo Pérez who, when venturing into the energy business renewable energy, determined that the Paragachi site, a community located 45 minutes from Ibarra (Imbabura), was the most suitable site for the installation of a photovoltaic plant, for which with the respective permit requested from CONELEC and an approximate investment of 2.3 million dollars, 4,160 panels were installed in an area of 3 hectares, which together from 07:00 to 17:00 generate 998 kilowatts, being able to reach 1,000 kilowatts on the sunniest days (photovoltaic, 2013) (Etxeberria et al., 2012; Zhang et al., 2014).

The plant will be connected to the same interconnected central system that is managed by Empresa Eléctrica del Norte (Emelnorte) and its production will satisfy 10% of Imbabura's total demand. With these palpable results, the projection of installing a second plant in Malchinguí with an approximate investment of 2.5 million dollars for a generation of around 995 kilowatts. Based on the above, according to the Electricity Corporation of Ecuador (CELEC EP, 2018) in Manabí, there is a high potential for the installation of a photovoltaic power plant, which would be located in the Aromo sector that corresponds to the rural area of the city of Manta, in the facilities that previously would have been used for the Pacific refinery project, which proposes to reduce around 128 thousand tons of CO2 per year and avoid the consumption of 7.9 million gallons of Fuel Oil per year, due to the replacement of thermal generation by photovoltaic (Sornichero, 2014; Houssamo et al., 2013).

It is worth noting that in the country a model has been developed for potential energy development from the use of endogenous resources (Pérez et al., 2020), this model is based on the analysis of the renewable potential that exists in the territory, caring for the environment and interaction with society. In December

2020, the "El Aromo" solar energy project was approved in the coastal province of Manabí, Ecuador. Operated by the Spanish company Solarpack, the project is expected to transform national solar production. El Aromo will occupy 2.9 km2 of land previously cleared to build a multi-million dollar oil refinery, plans that have since been abandoned (Open-Democracy, 2021)

While El Aromo has symbolic significance, it remains uncertain whether the project will mark a significant step towards a more environmentally sustainable energy development in Ecuador. Due to this, early works necessary for the subsequent construction of the refinery were carried out, including the El Aromo camp, located 10 km from the construction site of the future refinery, which would serve to house workers and professionals during the construction phase. construction of the industrial complex.

2 Materials and Methods

Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are The Geographic Information System (GIS) (García, 1991), was used as a work tool to manage the solar potential where the plant will be located, GIS is tool to help manage resources, land planning, transportation, energy, among others, constituting a fundamental element for local development, in addition to supporting decision-making based on specialized information, to solve complex problems, in addition to PSyst 7.1., A bibliographic review of information related to employment was carried out and the design of photovoltaic systems.

3 Results and Discussions

As part of the corporate strategy of social responsibility, the company Refinería del Pacífico had planned to transfer the administration of the camp to the mayor of Manta, after the construction of the refinery was completed, so that it could be donated to families of the El Aromo sector and contribute to the improvement of their quality of life. Currently, for political reasons, the new refinery project has been canceled, the mixed-economy company is in the process of being liquidated, and the El Aromo camp is ready to be transferred to the families of the El Aromo sector. The El Aromo photovoltaic project: will be in the slag heaps of the 1,500-hectare land that was destined, until recently, for the failed construction of the Pacific Refinery, in Manabí. In July 2020, this solar energy project would be awarded (Marucci & Cappuccini, 2016; Omrany et al., 2016). Figure 1 shows the El Aromo camp (former Pacific Refinery project).

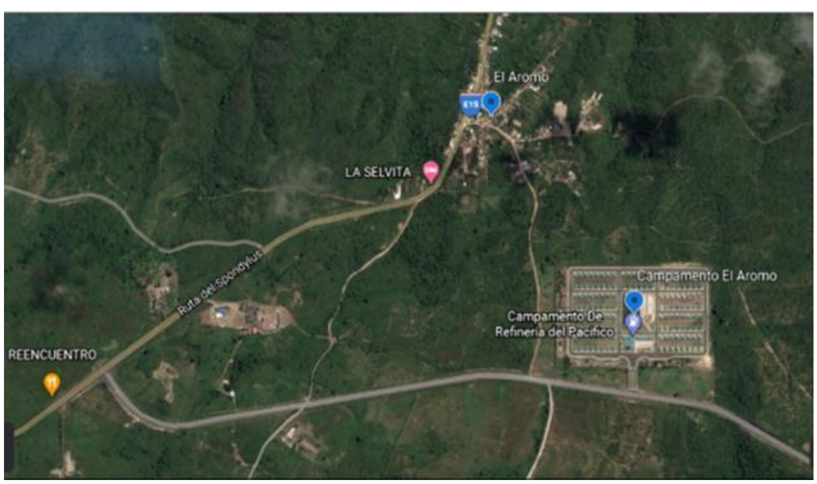

Figure 1. The geographical location of the Aromo camp
Source: Taken from Google Earth

It is identified that in the intervention area where the development of the project is planned, there is a low risk of flooding, as well as landslides; but seismic events such as the entire coastal profile of Ecuador is susceptible to this type of natural manifestation. El Aromo is in the third area with the highest solar potential in the province, with annual average values of horizontal irradiation between 4.82 and 5.22 kWh / m2 day, as shown on the map in figure 2 the solar potential of the canton Manta.

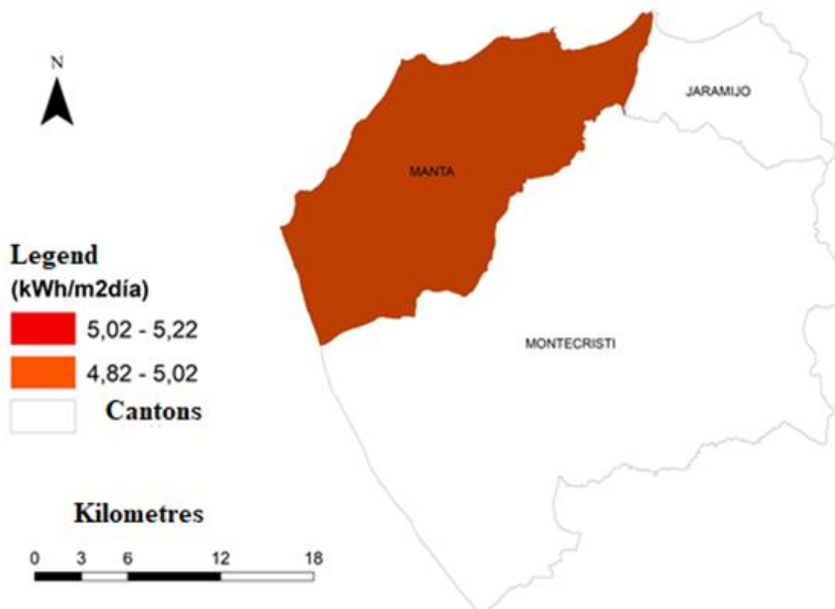

Figure 2. Map of the solar potential of the Manta canton
Source: Limones-Pozos et al. (2018)

Within the land where the camp of the old Pacific Refinery project is erected, there are 140 houses, which due to their structure can be used for the installation of the solar panels, under this premise the steps to follow for the respective installation are set out below:

1) First step: mount the supports of the photovoltaic installation
   Before placing the solar panels on the roof, it is necessary to place the supports for them on the roof. Depending on the type and inclination of this, the type of structure to be used will vary. For example, the support structure will not be the same in a roof whose modules are placed coplanar to it, as in a flat roof in which the modules have to be inclined in a certain way to obtain the highest possible efficiency of the system, and also weight the structure to avoid the so-called “sail effect” (that is, make sure that the panels and structure do not “fly away” due to the effect of the wind).
2) Second step: Fixing the roof and solar panels
   Once the structure is located, it must be fixed to the roof and the photovoltaic panels placed on it. Depending on its type and inclination, this process is carried out in different ways. The most usual thing is that the roof is inclined, between 20º and 35º, which favors performance; and Arabic-type tile, however, a different case may occur, such as slate tiles or flat roofs covered with asphalt fabric, among others. The anchoring of the support structure will vary depending on the roof on which it will be anchored. Once the structure is anchored on the roof, the modules are placed and fixed to it, after which they are interconnected with each other, to finally be connected to the inverter.
3) Third step: The connection to the electrical inverter
   The interconnection of the panels is carried out in series between the modules of the same row or string and in parallel to connect the rows depending on the panel/inverter configuration. This is done using so-called MC4 connectors to connect the modules in parallel, or directly to the inverter. It is

important to tighten the connectors strongly, since a bad connection will negatively affect the overall performance of the installation, causing possible problems such as so-called hot spots, which can also affect the structure of the panel itself. In this way, the total electrical generation of the module system is conducted to the same point, whose final destination is to reach the inverter.

Finally, a parallel connection is made, which can be made directly in the inverter, thus completing the part of the direct current (DC) installation, and thus being conducted all the energy collected by each panel through solar radiation in form of electrical current to the inverter, which will be located at a point near the electrical panel of the house (Aste et al., 2020; Toledo et al., 2010; Santosa & Yusuf, 2017). The inverter must be sheltered from the sun's rays, it is advisable to place it inside the house, or in case of not being able and to place it outside, to provide it with some element of protection. Figure 3 shows the connection diagram.

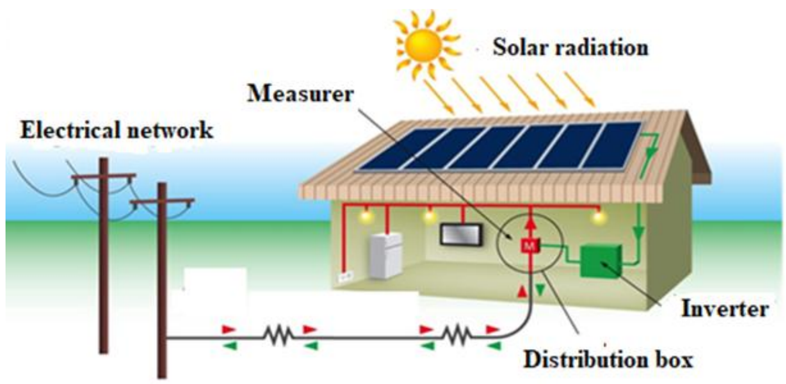

Figure 3. Connection diagram of the photovoltaic system

According to the work carried out, it is established that in the Manta canton there is a high potential for the generation of electricity using photovoltaic plants, thus promoting the use of clean energy and thus contributing to environmental conservation. Such is the case in the province of Manabí specifically in the rural sector. These types of installations can have a lifetime of approximately 30 years, it all depends on the type of material used and the natural conditions of the site where it is installed, it all depends on the working conditions, characteristics of the territory, among others (Rojas-Hernández & Lizana Moreno, 2018).

The calculation of the territorial space that presents feasibility conditions for the implementation of photovoltaic systems extends to a total of 166.43 km2, for 21.7% of the total territory of the municipality, the viable areas close to the substation. For the implementation of these systems, it is necessary within the investment, the assembly of a substation to provide the SEN with the energy generated by the photovoltaic modules, since it has a transformation substation, it is not necessary to build it, reducing costs for this. objective. The proposal for the introduction of this technology is intended to liberate the generation of electrical energy with conventional fuels (Hafez & Bhattacharya, 2012; Arcentales et al., 2017).

In relation to environmental aspects, according to the simulations carried out, during the useful life of the facilities that are expected to last 30 years with due preventive maintenance for their correct operation, an estimated saving of 141.6 tCO2 to the environment, with which it would be contributing to the reduction of greenhouse gases and consequently to reducing global warming. In the social and economic aspect, the execution of the project itself proposes the creation of workplaces for the installation of solar panels, in addition, once they are in operation, they must receive maintenance not only in the technical aspect but, because they are exposed to the environment Impurities that settle on the surface of these structures must be removed, requiring periodic cleaning (López & Frontini, 2014; Radomes Jr & Arango, 2015).

4 Conclusion

It was determined that the installation of the photovoltaic plant in El Aromo in Manta canton may be viable because it meets the conditions in its extension and location, counting on an infrastructure of 140 homes in which the structures can be installed taking advantage of them as their support. With the start-up of the project, it is expected to reduce the emission of 141.6tCO2 during the useful life of the facilities, in addition to avoiding the consumption of 7.9 million gallons of Fuel Oil per year, due to the replacement of generation thermal by photovoltaic. The social and economic impacts, the installation process promotes the acquisition of labor not only for the technical part but also workers, also during the period of operations maintenance of the facilities is required.

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References

Arafet, CMG, Cano, IM, Rivera, RR, Gámez, MR, & Pérez, AV (2014). Feasibility of installing grid-connected photovoltaic systems; Feasibility of installation of connected photovoltaic systems to grid. *Energy Engineering* , *35* (2), 141-148.

Arauz, W. M. S., Gámez, M. R., Pérez, A. V., Castillo, G. A. L., & Alava, L. A. C. (2017). The future of micro-grids in Ecuador. *International Journal of Physical Sciences and Engineering*, *1*(3), 1-8.

Arcentales, G. A. T., Gordin, R. G., Perez, A. V., & Rodriguez, A. Z. (2017). Climatization, energy efficiency and environmental protection. *International Research Journal of Engineering, IT & Scientific Research*, *3*(2), 59-66. Retrieved from https://sloap.org/journals/index.php/irjeis/article/view/532

Aste, N., Caputo, P., Del Pero, C., Ferla, G., Huerto-Cardenas, H. E., Leonforte, F., & Miglioli, A. (2020). A renewable energy scenario for a new low carbon settlement in northern Italy: Biomass district heating coupled with heat pump and solar photovoltaic system. *Energy*, *206*, 118091. https://doi.org/10.1016/j.energy.2020.118091

Etxeberria, A., Vechiu, I., Camblong, H., & Vinassa, J. M. (2012). Comparison of three topologies and controls of a hybrid energy storage system for microgrids. *Energy Conversion and Management*, *54*(1), 113-121. https://doi.org/10.1016/j.enconman.2011.10.012

Fernández, H., Martínez, A., Guzmán, V., & Gímenez, M. I. (2008, September). A simple, low cost design using current feedback to improve the efficiency of a MPPT-PV system for isolated locations. In *2008 13th International Power Electronics and Motion Control Conference* (pp. 1947-1950). IEEE.

García, A., (1991). "An approach to the dynamic mapping of land occupation: Test in the Area of Mondéjar (Guadalajara) ", Geographical Studies Magazine, Madrid, October-December 1991, vol.52, n.205, p. 625-652, e-ISSN 1988-8546.

Hafez, O., & Bhattacharya, K. (2012). Optimal planning and design of a renewable energy based supply system for microgrids. *Renewable Energy*, *45*, 7-15. https://doi.org/10.1016/j.renene.2012.01.087

Houssamo, I., Locment, F., & Sechilariu, M. (2013). Experimental analysis of impact of MPPT methods on energy efficiency for photovoltaic power systems. *International Journal of Electrical Power & Energy Systems*, *46*, 98-107. https://doi.org/10.1016/j.ijepes.2012.10.048

Limones-Pozos, C. A., Martínez-Rodríguez, P. R., Sosa, J. M., Vázquez, G., & Izaguirre-Vera, A. (2018, November). Design and analysis of a single-phase transformerless multilevel 7L-TT-HB cascade inverter for renewable energy applications. In *2018 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC)* (pp. 1-6). IEEE.

López, C. S. P., & Frontini, F. (2014). Energy efficiency and renewable solar energy integration in heritage historic buildings. *Energy Procedia*, *48*, 1493-1502. https://doi.org/10.1016/j.egypro.2014.02.169

Marucci, A., & Cappuccini, A. (2016). Dynamic photovoltaic greenhouse: Energy efficiency in clear sky conditions. *Applied Energy*, *170*, 362-376. https://doi.org/10.1016/j.apenergy.2016.02.138

Omrany, H., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Raahemifar, K., & Tookey, J. (2016). Application of passive wall systems for improving the energy efficiency in buildings: A comprehensive review. *Renewable and sustainable energy reviews*, *62*, 1252-1269. https://doi.org/10.1016/j.rser.2016.04.010

Pérez, AV, Araus, WMS, Viteri, CGV, & Gámez, MR (2020). A model for sustainable energy development. The university, geography and endogenous resources / A model for sustainable energy development. The university, geography and endogenous resources. *Venezuelan Geographic Magazine* , *61* (1), 220-234.

Poblano Ortiz, E. S., Romantchik Kriuchkova, E., Hahn Schlam, F. F., Betanzos Castillo, F., & Martínez Castellanos, T. (2015). Comparison of costs of photovoltaic systems for greenhouses and network electricity expenses. *Revista mexicana de ciencias agrícolas*, *6*(4), 679-693.

Radomes Jr, A. A., & Arango, S. (2015). Renewable energy technology diffusion: an analysis of photovoltaic-system support schemes in Medellín, Colombia. *Journal of Cleaner Production*, *92*, 152-161. https://doi.org/10.1016/j.jclepro.2014.12.090

Rojas-Hernández, I., & Lizana Moreno, F. (2018). Energy recovery time for photovoltaic systems based on crystalline silicon in Costa Rica. *Energy Engineering* , *39* (3), 195-202.

Santosa, I. G., & Yusuf, M. (2017). The application of a dryer solar energy hybrid to decrease workload and increase dodol production in Bali. *International Research Journal of Engineering, IT & Scientific Research*, *3*(6), 99-106. Retrieved from https://sloap.org/journals/index.php/irjeis/article/view/14

Sornichero, L.J. (2014). Renewable energy. Didactic proposal. *Ribalta: Quaderns d'didactic application and research* , (21), 23-32.

Toledo, O. M., Oliveira Filho, D., & Diniz, A. S. A. C. (2010). Distributed photovoltaic generation and energy storage systems: A review. *Renewable and Sustainable Energy Reviews*, *14*(1), 506-511. https://doi.org/10.1016/j.rser.2009.08.007

Zhang, L., Gari, N., & Hmurcik, L. V. (2014). Energy management in a microgrid with distributed energy resources. *Energy Conversion and Management*, *78*, 297-305. https://doi.org/10.1016/j.enconman.2013.10.065

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