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Research article

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Proposal for a photovoltaic system at the University of Moa

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Abstract

Currently, the energy matrix worldwide relies on fossil fuels and the rate of consumption is increasing, so that the depletion of existing reserves is a reality that concerns everyone. The objective of this work was to propose a photovoltaic system on the roof of the kitchen-dining room building of the University of Moa, on which the energy that it is capable of delivering was determined. A simulation of it was carried out in the PV syst software. The results indicated that the installation generates 351 MWh per year with an installed capacity of 230 kW and the installation is made up of 851 photovoltaic modules occupying a useful area of 1.390 m².

Keywords: Energy, Photovoltaic System.

Introduction

Some studies suggest that the electricity service plays an important role in the social, economic and environmental sphere of any territory [1-3]. Currently, the energy matrix worldwide relies on fossil fuels and the rate of consumption is increasing, so that the depletion of existing reserves is a reality that concerns everyone.

Although the use of alternative or unconventional sources is far from being shown, in the short term, as the definitive solution to energy supply problems or as a substitute for traditional ways of obtaining it, the participation of photovoltaic energy in the generation of electricity is increasing and has aroused the interest of many researchers around the world in the quality of generation and economic viability, as well as its environmental effect [4-7].

On the other hand, the emission of gases from the burning of fossil fuels is a severe problem that currently seriously affects the planet, so the call made by the various organizations that support its preservation is permanent, allowing the development of actions that minimize the negative effects generated by the development of society itself. In this sense, in Cuba, a very significant change is taking place in the energy culture focused on the use of renewable energy sources, taking advantage of the availability of each territory [8-10].

The objective of this work is to propose a photovoltaic system to be located on the roof of the kitchen-dining room building of the University of Moa, by simulating it in the PV syst software.

Materials and Methods

Case Study

The proposal is made on the roof of the kitchen-dining room building for the students, whose dimensions are 60x40 m, with coordinates 20.70 north latitude and 75.00 west longitude at 15 m of altitude above sea level.

In figure 1 you can see a satellite photo of the location of the photovoltaic system.

Figure 1: Satellite view of the kitchen-dining room building PV syst software

For the simulation of the photovoltaic system, PVSyst software is considered, which is considered by several researchers as a tool with good performance and precision in the results [10].

This software has the ability to calculate daily values of solar radiation from monthly measurements. It also contains all the subprograms for the design, optimization and simulation of four types of systems: connected to the grid, autonomous, solar pumping and direct current networks. It also includes a database with 7200 PV module models and 2000 inverter models. One of the potentialities of the PV syst is that it provides information on the solar trajectories of the locality, allowing to determine the losses due to the effect of nearby shadows during all year.

Photovoltaic Modules

The photovoltaic module selected is from the DSM – 270 series; It is made up of 60 solar cells of 156.75x156.75 mm format, connected in series. The fundamental characteristics and technical specifications are represented in table 1.

Table 1: Characteristics and technical specifications of the DSM-270 series modules

Especificaciones técnicas	
Celda	Celda Solar de Silicio Multicristalino 156,75mm x 156,75mm
No. De celdas y conexiones	60 (6x10)
Dimensiones del módulo	1650mm x 990mm x 40mm
Cubierta frontal	Vidrio templado
Material del marco	Aleación de aluminio anodizado
Peso	18,1
Características eléctricas	
Modelos	DSM-270
Voltaje a circuito abierto	38,0
Voltaje en el punto de máxima potencia	32,1
Corriente de corto circuito	9,11
Corriente en el punto de máxima potencia	8,42
Potencia máxima a STC	270
Tolerancia	± 3

Environmental Effect

Thermoelectric Power Plants emit into the environment a certain amount of polluting gases produced by combustion, some of the most significant being Sulfur Dioxide (SO2), Sulfur Trioxide (SO_3), Nitrogen Monoxide (NO), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Carbon Dioxide (CO_2) and Hydrocarbons (CH_4 and C_2H_4).

The environmental effect considered in this research is based on the reduction of polluting gas emissions due to energy saving through equation (1), proposed in the literature consulted [11, 12].

$$Emisiones = FE \cdot Ea \qquad (1)$$

Where FE is the emission factor and Ea is the energy saved in the year.

Contaminantes	Factor de emisión g / kWh
NO_x	3.41
CO_2	0.23
CO	799
HC	0.083
SO_2	0.0984

Figure 2: Emission factor values for each polluting gas corresponding to a Thermoelectric Power Plant

Results

The number of photovoltaic modules to be used is 851 modules occupying a useful area of 1390 m2, with the recommendation of the PVsyst to connect 23 modules in series and 37 modules in parallel, for a capacity of 230 kW. Figure 3 shows the simulation carried out in said software. An optimal inclination of the panels of 180 is considered.

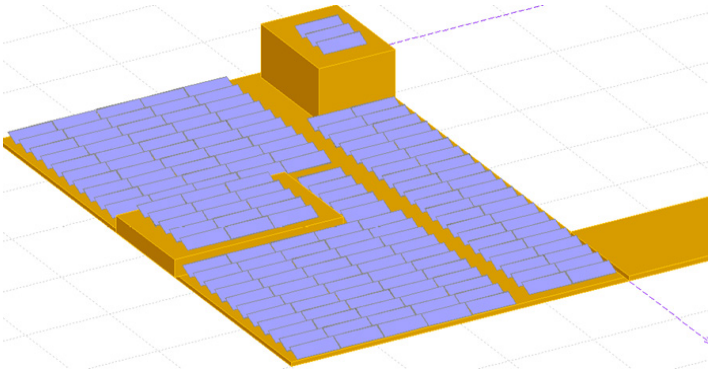

Figure 3: Disposition of the panels in the area.

Figure 4 shows that losses due to shading occur before 9:00 a.m. and after 5:00 p.m. The local evolution of the daily solar trajectories allows us to affirm that shadow losses are greater in winter, but in general they are very small throughout the year.

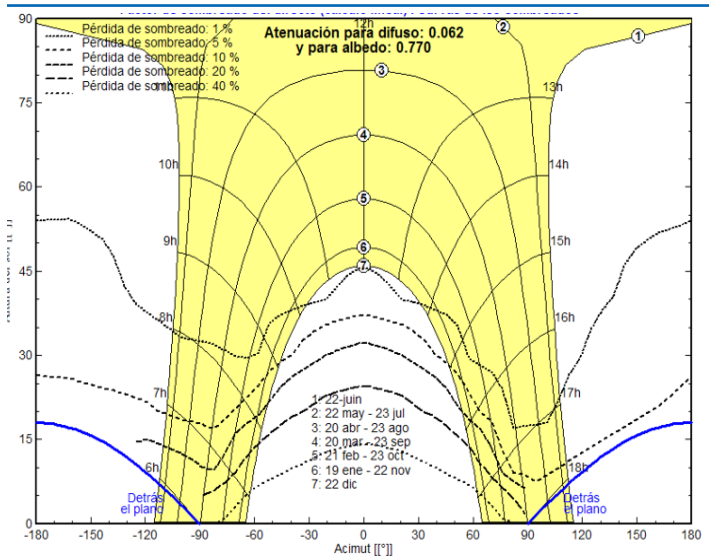

Figure 4: Installation shadow factor

Performance Ratio and energy

Figure 5 shows the Performance Index for the different months of the year. Note that the values remain relatively stable for the entire year, with an average value of 0.769.

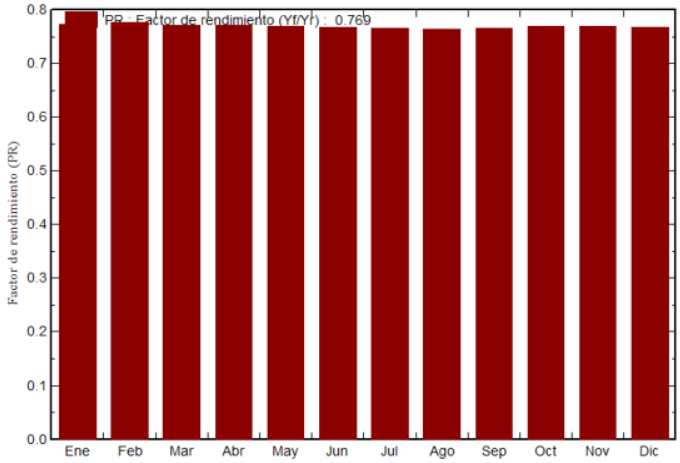

Figure 5: Behavior of the Performance Ratio for the different months of the year

Figure 6 shows the diagram of losses throughout the year and the energy generated by the photovoltaic installation with a total of 351 MWh to be delivered to the grid in this period of time.

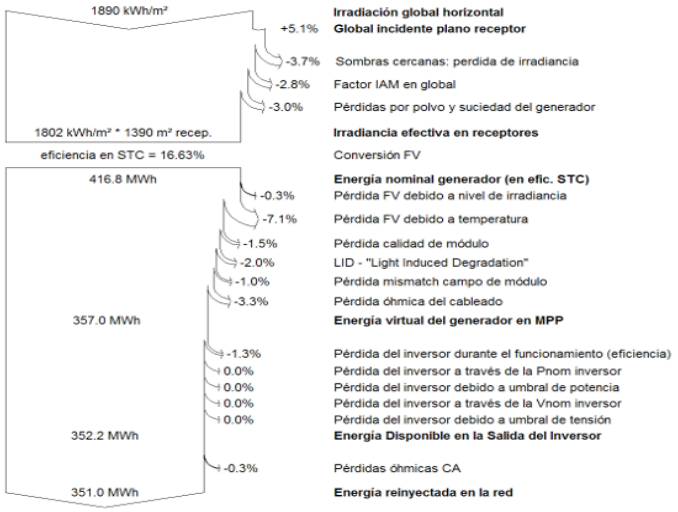

Figure 6: Loss and energy diagram of the photovoltaic installation

Environmental effect

Based on the results of the simulation, the influence of the installation of a photovoltaic system on the kitchen-dining room roof of the University of Moa is determined.

Table 2 shows the values corresponding to the polluting gases for the concept of saving fuel that is stopped burning by a Thermoelectric Power Plant.

Table 2: Results of pollutants no longer emitted into the atmosphere

Contaminantes	Emisones (ton/año)
NOx	1.20
CO_2	0.08
CO_2	280.45
HC	0.03
SO_2	0.03
Total	281.79

Taking into account the results of Table 2, with the photovoltaic installation, a total of 281.79 tons of polluting gases are no longer emitted into the atmosphere per year.

Conclusions

- The energy generated by the photovoltaic system proposed on the roof of the kitchen-dining room building of the University of Moa is 351 MWh per year, with a total of 851 photovoltaic modules connected and a capacity of 230 kW.
- The Performance Ratio remains practically unchanged throughout the year, averaging a value of 0.769.
- The installation of this photovoltaic system implies an impact of reducing emissions of polluting gases equal to 281.79 tons per year.

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