Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Ambiental

Tesis

Technical Feasibility and Optimization of Photovoltaic Solar Panels in the Central Area of Peru

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Para optar el Título Profesional de
Ingeniero Ambiental

Huancayo, 2024

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Technical Feasibility and Optimization of Photovoltaic Solar Panels in the Central Area of Peru

URL / DOI:
https://link.springer.com/chapter/10.1007/978-3-031-54394-4_4

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TECHNICAL FEASIBILITY AND OPTIMIZATION OF PHOTOVOLTAIC SOLAR PANELS IN THE CENTRAL AREA OF PERU

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ABSTRACT

This work evaluates the technical feasibility of installing photovoltaic solar panels for homes in the city of Huancayo, Peru. For this, variables such as: solar radiation, orientation, angle of inclination and electrical power were taken into account. The development of the study was carried out in the renewable energy laboratory of the electrical and electronic engineering faculty of the National University of Central Peru, which is located in the city of Huancayo. The prototype used was model YI6R-30P, polycrystalline silicon at 30 watts and 12 VDC. With the objective of optimizing the variables of the study for the efficient use of the solar panels that are being used in the present work. The data collection was evaluated in 3 consecutive months of this year, where the electrical power generated according to the solar radiation obtained during each month, with an orientation (0°N and 45°NE), and angle of inclination has been measured. (13th and 16th). In conclusion, the most efficient design is: 7 hours of high solar radiation, with an inclination angle of 16°, oriented towards the North-East, and electrical power of 20 watts.

Keywords: Angle of inclination, Electric power, Photovoltaic solar panel.

1. INTRODUCTION

The use of resources has impacted humanity in a significant way, making science advance against global warming[1]. The growing demand for energy motivates the search for better ways to meet our needs that increases with the passage of time, making resources such as: oil, coal, natural gas, uranium, among others become scarce[2]. Therefore, clean technologies have been developed that help reduce the impact on the ecosystem. Alternative energies such as hydroelectric, wind and solar allow us to use resources sustainably since they are considered inexhaustible sources and therefore renewable[3]. Solar energy today is used more frequently than photothermal and

photovoltaic, between these they differ because one takes advantage of the heat produced by the sun to heat the water and the other generates electricity through sunlight[4]. Photovoltaic solar energy is considered the most promising of renewable energies[5]. It is available anywhere in the world and avoids environmental pollution[6]. Photovoltaic solar energy makes use of panels made up of cells, in which an electrical potential difference is generated, where electrons jump from one place to another, producing electrical energy[7]. The energy, absorbed by these panels depends on the angle of inclination, the orientation and the solar incidence of the place where it is located[8].

For the efficient use of photovoltaic solar panels, the variables to consider are: solar radiation, which reaches the surface of the planet in the form of electromagnetic waves and its intensity varies depending on the hemisphere, parallel and meridian of the earth[9]; as well as: orientation, since photovoltaic panels are more effective when solar rays enter perpendicularly, in addition to evaluating the geography of the place[10], therefore, the next variable to take into account is the angle of inclination of the panel on the surface where it will be placed, because this will depend on the time of year and the aforementioned factors[11].

In recent years, the optimization of the inclination angle of solar panels has been studied with greater importance, since several authors affirm that the efficiency of the solar panel is affected by the location, latitude, elevation and day of the year[12], as in the investigation of: “A generalized approach for the determination of optimum tilt angle for solar photovoltaic modules with selected locations in Ethiopia as illustration examples”[13], where the authors conclude that the optimal tilt angle for the winter season is 35.33° and for the summer 0°; in another investigation, “Theoretical and experimental investigation of photovoltaic cell performance, with optimum tilted angle: Basra city case study ”[14], where the researchers experimented with solar panels at different angles in a range from 0° to 90°, obtaining that in the city of Basra the optimal angle of inclination is equal to 28°. Since each place has different geographical and climatic characteristics, the efficiency of these solar panels will depend on their location[15]. Therefore, this research is motivated by studying the optimal technical feasibility of the photovoltaic solar panel system in Huancayo city.

2. MATERIALS AND METHODS

The research took place in Peru, in Junín department, province of Huancayo, located in the central mountain range of the country, whose geographical coordinates are: latitude -12.06413 and longitude -75.20486, latitude 12° 4' 5" South and longitude 75° 12' 38" West, zone 18 South, at 3259 masl. In this area there are two very marked seasons, rainy and dry, the climate is between temperate and dry, with an average temperature of 12°C.

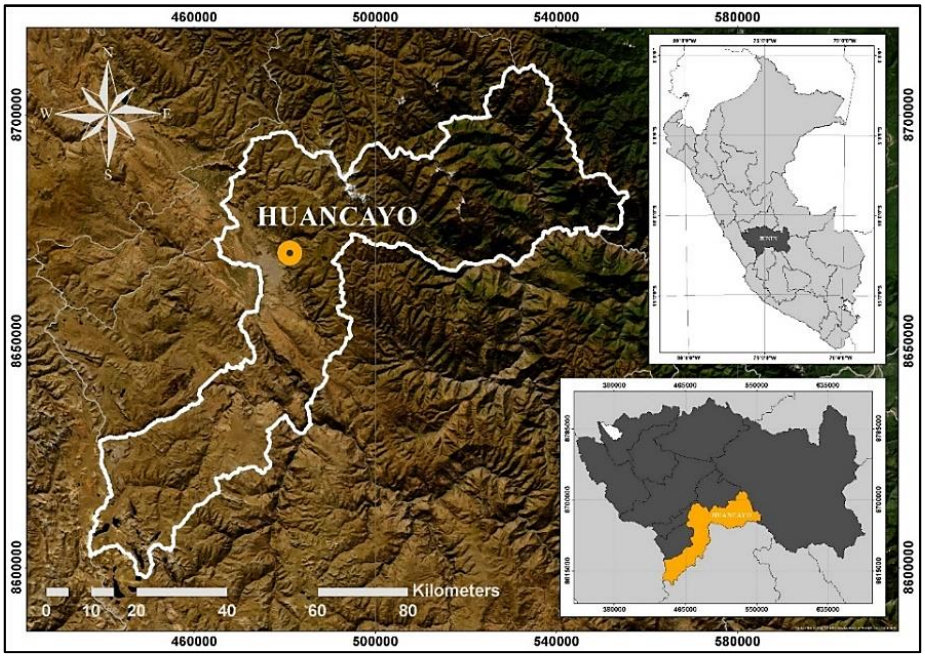

Figure 1. Location map of the city of Huancayo, place where the research was carried out.

The materials used were two YI6R-30P models, solar panels with 110 mm polycrystalline silicon cells, 634 mm long and 349 mm wide, 30 watts and 12 VDC. These photovoltaic panels were located on the second floor of the pavilion of the National University of the Center of Peru (UNCP), in the renewable energy laboratory of the faculty of electrical and electronic engineering, in an area with ample space to receive the largest collection of solar radiation. In addition, support was used that allowed manipulating the solar panels at the different inclination angles and

orientations studied. The measurements were taken at peak hours when the solar incidence was the maximum.

Figure 2. Photovoltaic solar panels, with a support frame.

3. Results and discussion

For the development of the research work, the variables of radiation, orientation, angle of inclination and electrical power were taken into account. The study was carried out during August, September and October, since spring begins on September 21, thus evaluating the dry season in transition to the rainy season.

Table 1. Table for August with the variables studied.

MONTH OF AUGUST						
N°	**Hour**	**Orientation**	**Angle**	**Voltage (V)**	**Amperage (A)**	**Power (W)**
1	12:00:00 p.m.	N 0°	13°	13.50	1.50	20.25
2	12:00:00 p.m.	N 45° E	13°	13.50	1.50	20.25
3	12:00:00 p.m.	N 0°	16°	13.60	1.50	20.40
4	12:00:00 p.m.	N 45° E	16°	13.50	1.50	20.25
5	02:35:00 p.m.	N 0°	13°	13.30	1.20	15.96
6	02:35:00 p.m.	N 45° E	13°	13.40	1.10	14.74
7	02:35:00 p.m.	N 0°	16°	13.40	1.20	16.08
8	02:35:00 p.m.	N 45° E	16°	13.30	1.10	14.63

Table 2. Table for September with the variables studied.

MONTH OF SEPTEMBER						
N°	**Hour**	**Orientation**	**Angle**	**Voltage (V)**	**Amperage (A)**	**Power (W)**
1	12:00:00 p.m.	N 0°	13°	13.50	0.90	12.15
2	12:15:00 p.m.	N 45° E	13°	17.10	1.20	20.52
3	12:20:00 p.m.	N 0°	16°	17.40	1.10	19.14
4	12:30:00 p.m.	N 45° E	16°	17.30	1.10	19.03
5	12:40:00 p.m.	N 0°	13°	13.70	0.80	10.96
6	12:50:00 p.m.	N 45° E	13°	15.00	1.00	15.00
7	13:00:00 p.m.	N 0°	16°	18.00	0.90	16.20
8	13:15:00 p.m.	N 45° E	16°	17.80	0.90	16.02

Table 3. Table for October with the variables studied.

MONTH OF OCTOBER						
N°	**Hour**	**Orientation**	**Angle**	**Voltage (V)**	**Amperage (A)**	**Power (W)**
1	10:15:00 a.m.	N 0°	13°	13.40	0.50	6.70
2	10:27:00 a.m.	N 45° E	13°	13.30	0.30	3.99

3	10:42:00 a.m.	N 0°	16°	13.40	0.40	5.36
4	11:00:00 a.m.	N 45° E	16°	13.50	0.40	5.40
5	11:15:00 a.m.	N 0°	13°	13.50	0.30	4.05
6	11:25:00 a.m.	N 45° E	13°	13.50	0.40	5.40
7	11:35:00 a.m.	N 0°	16°	13.60	0.50	6.80
8	11:55:00 a.m.	N 45° E	16°	13.60	0.50	6.80

3.1. Solar radiation

The measurement of solar radiation was evaluated for twelve hours, from 6:00 am to 6:00 pm, for three months. In Huancayo, these months do not present rain, which is known as the dry season. Where we have high levels of radiation, because in this season there is low cloudiness, therefore, radiation between 8:30 am and 3:30 pm is high.

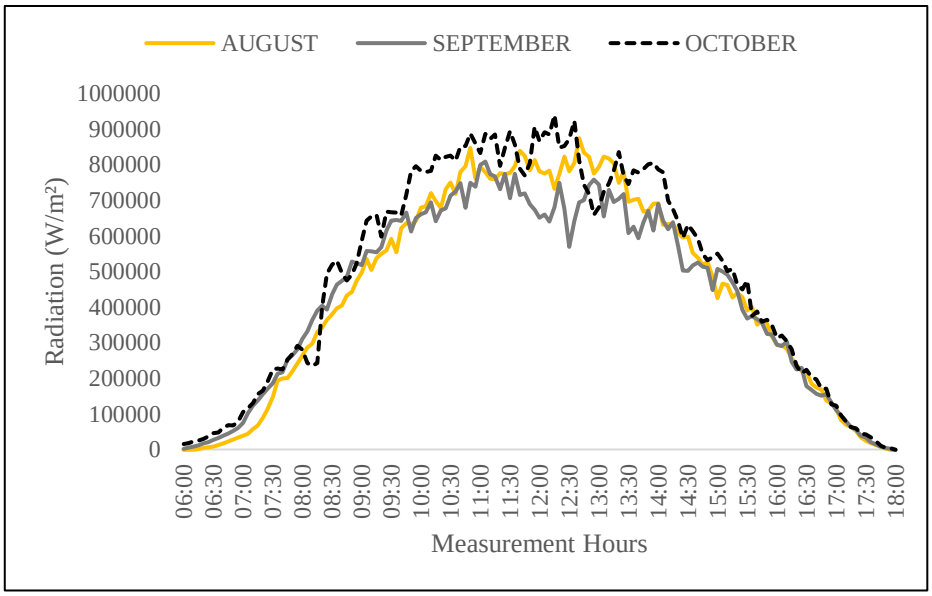

Figure. 3. Radiation was evaluated between 6:00 am and 6:00 pm in the months studied.

3.2. Orientation

The efficient operation of the photovoltaic solar panel depends on the orientation, and this variable is affected by the area where we are located, the place is a valley with two mountain ranges to the east and west, in addition to being in the southern hemisphere, near the equator. For this reason, it has been considered to study two types of

orientations, 0°N and 45°NE. The results for August, September and October are shown below.

Orientation 0° North

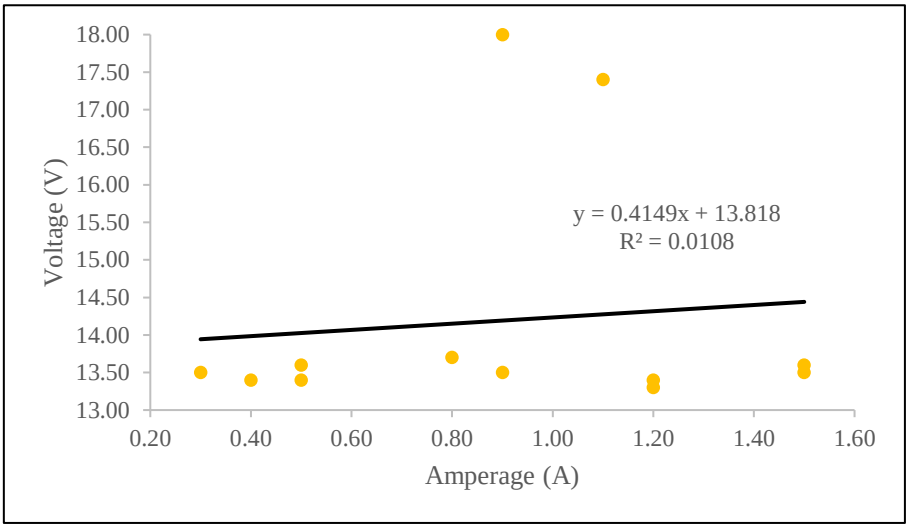

Figure 4. Graph of Voltage vs. Current Intensity for Orientation 0°N.

In figure 4 we have the graph for the 0°N orientation, on the axis "x", the variable Current intensity (A) and on the axis "y", the variable Voltage (V); obtaining according to linear regression the following equation:

$$Y = 0.4149x + 13.818$$

$$R^2 = 0.0108$$

Where the variable Voltage (V) has a growth at a rate of 0.4149 times the variable Current Intensity. The level of reliability of the projection is 0.0108, low and unreliable.

Orientation North 45° East

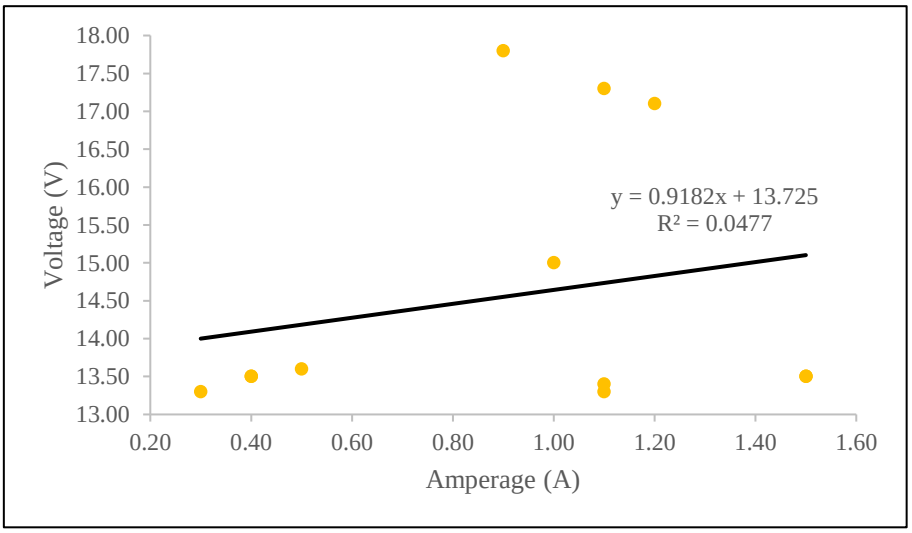

Figure 5. Graph of Voltage vs. Current Intensity for the Orientation 45°NE.

In figure 5 we have the graph for the 0°N orientation, on the "x" axis, the variable Current intensity (A) and on the "y" axis, the variable Voltage (V); obtaining according to linear regression the following equation:

$$Y = 0.9182x + 13.725$$

$$R^2 = 0.0477$$

Where the variable Voltage (V) has a growth at a rate of 0.9182 times the variable Current Intensity. The level of reliability of the projection is 0.0477, high and reliable.

Orientation in the Electric Power variable

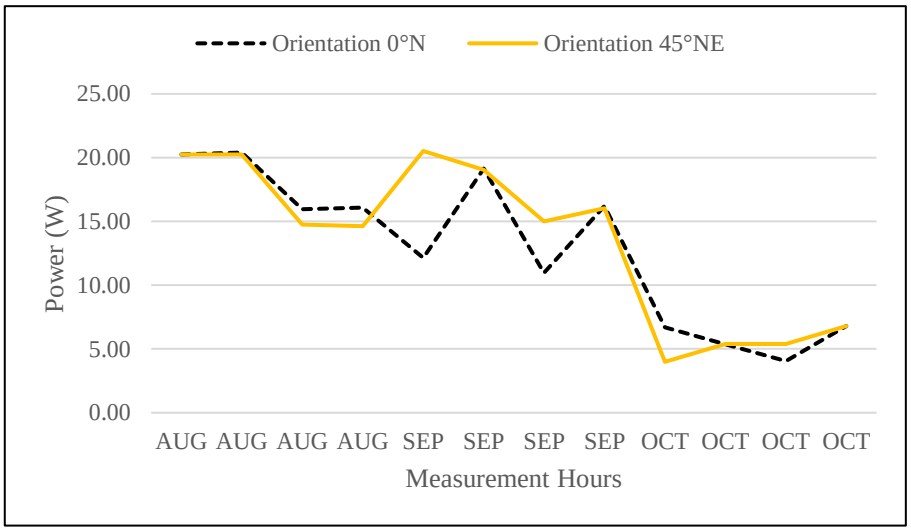

Figure 6. The graph shows the influence of orientation on the electrical power of the solar panel.

In figure 6, the North 45° East orientation presents high values of electrical potential compared to the North 0° orientation, during the months evaluated, therefore, it is concluded that for the city of Huancayo, the optimal orientation of the panels solar photovoltaics is in the direction 45°NE.

3.3. Inclination angle

Many investigations evaluate the angles of inclination from 0° to 90°, for this case, we focus on studying the behavior of the power of the solar panel concerning the angles of 13° and 16°, due to the trajectory of the sun that presents in Huancayo city.

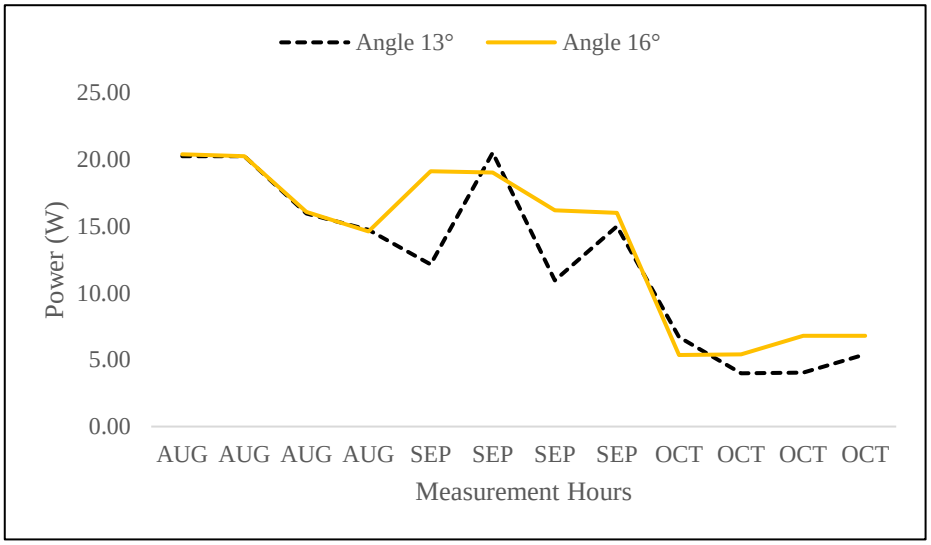

Figure 7. Influence graph of the angle of inclination in the electrical power variable.

Figure 7 shows how the different inclination angles influence the electrical power during the months studied, for the angle of 13°, the highest electrical power peak is 20.52 W and the lowest is 3.99 W, for the 16° angle, the highest electrical power peak is 20.40 W and the lowest is 5.36 W, however, the 16° angle presents more constant results compared to the 13° angle. Therefore, it is concluded that the angle of 16° is the most optimal to use in the city of Huancayo.

4. Conclusions

After evaluating the variables, we can conclude that solar radiation is optimal since, of the 12 hours of solar availability, there are 7 hours of high solar incidence. The orientation of the photovoltaic panel must be directed toward the North -East, due to the geography of the place, which is located in a valley in the south, concerning the equator. The angle of inclination with the greatest capture turns out to be 16°. Therefore, the operation of the photovoltaic solar panel system presents optimal technical feasibility to be developed in the city of Huancayo.

As a recommendation, the use of these clean technologies should be promoted, which helps to reduce the environmental impact. It is important to continue carrying out this type of study that allows us to demonstrate that alternative energies are capable of feeding/satisfying the basic needs of a home.

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