ECORFAN-Journal Taiwan 8[15]1-7: e4815107

Article

Effect of the angle of solar irradiance on the photo generation of a photovoltaic module

Efecto del ángulo de incidencia solar en la foto generación de un módulo fotovoltaico

Castillo-Campos, Nohemí Alejandra [a], Palacio-Sifuentes, David Isaac [b], Escobedo-Márquez, Diana Laura [c] and Álvarez Macías, Carlos *[d]

[a] ROR Tecnológico Nacional de México/Instituto Tecnológico de La Laguna • LKK-0500-2024 • 0009-0001-2490-4325 • 1271718.
[b] ROR Tecnológico Nacional de México/Instituto Tecnológico de La Laguna • LDG-3672-2024 • 0009-0009-7454-5808 • 1305504.
[c] ROR Tecnológico Nacional de México/Instituto Tecnológico de La Laguna • LKK-0506-2024 • 0009-0005-9859-8251 • 1188232.
*[d] ROR Tecnológico Nacional de México/Instituto Tecnológico de La Laguna • H-3977-2017• 0000-0002-2263-0316 • 165872

CONAHCYT classification:

Area: Engineering
Field: Engineering
Discipline: Energy engineering
Subdiscipline: Solar energy

https://doi.org/10.35429/EJT.2024.8.15.4.7

History of the article:
Received: April 11, 2024
Accepted: December 21, 2024

Check for updates

* ✉ [calvarezm@correo.itlalaguna.edu.mx]

Abstract

The correct installation of a photovoltaic system is vital to obtain the expected generation when sizing the energy that will be needed, since photovoltaic technology is constantly exposed to factors that can reduce its efficiency. In this work, the effect of the angle of solar incidence on the surface of a module was analyzed, through the comparison of the power generated at different angles of inclination from 10 to 45°, and giving the module different angles of orientation from east to west passing through the south (90° to -90° in the azimuth). The behavior of irradiance over time was also analyzed. Derived from this study, it was found that, for the city of Torreon, Coahuila, Mexico photovoltaic modules should be installed facing south and with an inclination of 25°, in addition, the region has an average HSP of 6 hours that occur around noon

Effect of the angle of solar incidence on the photo generation of a photovoltaic module		
Objectives	**Metodology**	**Contribution**
• Analyze the photogeneration of a photovoltaic module according to its inclination and orientation • Check the correct installation parameters for a photovoltaic module in the city of Torreón, Coahuila.	• Evaluation of irradiance reception according to the peak solar hours of the region. • Obtaining efficiency of the module by positioning it with the correct orientation, but varying the inclination. • Analysis of the power loss factor according to the variation of the orientation of the module in the azimuth plane.	The study graphically and mathematically demonstrates the relationship between the orientation and inclination of a photovoltaic module with the energy generation obtained from it, this specifically for the region in which the analysis was carried out.

Photovoltaic energy, Angle incidence, Efficiency

Resumen

La correcta instalación de un sistema fotovoltaico es vital para obtener la generación esperada al momento de dimensionar la energía que se necesitará, esto ya que la tecnología fotovoltaica se expone constantemente a factores que pueden reducir su eficiencia. Es este trabajo se analizó el efecto del ángulo de incidencia solar sobre la superficie de un módulo, a través de la comparación de la potencia generada a distintos ángulos de inclinación de los 10 a 45°, y dando al módulo diferentes ángulos de orientación de es este a oeste pasando por el sur (90° a -90° en el azimut). Así mismo se analizó el comportamiento de la irradiancia en el trascurso del tiempo. Derivado de este estudio se encontró que, para la ciudad de Torreón, Coahuila, México los módulos fotovoltaicos deben instalarse viendo al sur y con una inclinación de 25°, además, la región cuenta con un promedio de HSP de 6 horas que se dan alrededor del mediodía

EFECTO DEL ÁNGULO DE INCIDENCIA SOLAR EN LA FOTO GENERACIÓN UN MÓDULO FOTOVOLTAICO		
Objetivos	**Metodología**	**Contribución**
• Analizar la foto generación de un módulo fotovoltaico de acuerdo a la inclinación y orientación del mismo • Comprobar los parámetros correctos de instalación para un módulo fotovoltaico de la ciudad de Torreón, Coahuila.	• Evaluación de la recepción de irradiancia de acuerdo a las horas solares pico de la región. • Obtención de eficiencia del módulo posicionándolo con la orientación correcta, pero variando la inclinación. • Análisis del factor de perdida de potencia según la variación de la orientación del módulo en el plano azimutal.	El estudio demuestra gráfica y matemáticamente la relación de la orientación y la inclinación de un módulo fotovoltaico con la generación de energía que se obtiene del mismo, esto en especifico para la región en que se realizó el análisis.

Energía fotovoltaica, Ángulo de incidencia, Eficiencia

Citation: Castillo-Campos, Nohemí Alejandra, Palacio-Sifuentes, David Isaac, Escobedo-Márquez, Diana Laura and Álvarez Macías, Carlos. [2024]. Effect of the angle of solar irradiance on the photo generation of a photovoltaic module. ECORFAN-Journal Taiwan. 8 [15]1-7: e4815107.

1. Introduction

Solar irradiance (G), defined as "the radiant flux density of the sun," differs from the radiation emitted by the sun as it is attenuated by the square of the distance between the sun and the surface it reaches. In the case of the irradiance that reaches Earth, the solar constant has been established (Perpignan, 2007).

Although this value may vary depending on the study, the World Meteorological Organization accepts an average value of 1367 W/m². However, this value is reduced by approximately 30% as it passes through the Earth's atmosphere, resulting in a final value of 1 kW/m² (*Perpignan, 2007*).

Due to atmospheric dispersion, global radiation, typically referred to as G_g, is composed of two components: direct radiation (G_b), which originates directly from the solar disk and reaches a specific location, and diffuse radiation (G_d), which is the radiation coming from the entire sky except from the solar disk (*Montoya, 2011*). The expression for global radiation is given in Equation 1.

$$G_g = G_b \times cos\, \theta_z + G_d \quad [1]$$

Where θ_z is the zenith angle θ_z.

Box 1

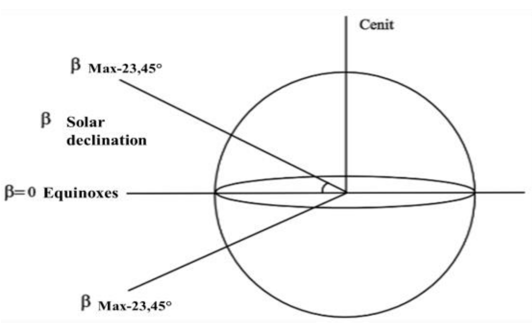


Figure 1
Angles that refer to the position of the sun with respect to apparent motion

The irradiance received at a point on a surface depends on what is known in solarimetry as the apparent motion of the sun, which is influenced by parameters such as the day of the year, time of day, and the sun's position. The sun's path is described by two angles: the zenith angle and the azimuth angle, both illustrated in Figure 1.

The zenith angle θ_z measures how far the sun is from the vertical at any given time, while the azimuth angle γ_s measures the sun's deviation from true south (*Marcial, 2019*).

In addition to the zenith and azimuth angles, another angle often used in solarimetry is the solar height or elevation angle. This angle measures the deviation of the sun from the horizontal, indicating its elevation in the sky.

The solar height angle is complementary to the zenith angle, meaning their sum equals 90°, as shown in Equation 2 (*Marcial, 2019*).

$$\theta_z + \alpha_s = 90° \quad [2]$$

The angle formed between the Earth's equator and the ecliptic is 23° 16' 30", which causes the sun's trajectory to change throughout the year. This variation gives rise to the solar declination angle, δ\deltaδ, defined as the "angle formed by the direction of the sun's rays with the plane of the equator" (*Rodríguez et al, 2022*).

The solar declination can be calculated daily with reasonable accuracy using Equation 3.

$$\delta = 23.45°\, sin\, sin \left[\left(\frac{360°}{365}\right)(284 + N)\right] \quad [3]$$

Where N represents the day of the year. This equation reflects that, throughout the year, the irradiance received on a surface change continuously.

The solar incidence angle refers to the angle at which sunlight strikes a surface. Based on the apparent motion of the sun, it follows that when the sun is near the zenith, the surface tends to receive a greater amount of energy.

This occurs because the path traveled by the sun's rays is shorter when the sun is at its maximum elevation, as shown in Figure 2, where distances X are longer than distance Y.

From this concept arises irradiation, which is the total irradiance received by a surface over a specific period of time. The hours of the day with the highest irradiance are referred to as Peak Sun Hours (PSH) (*Style, 2012*).

The performance of a photovoltaic module is directly proportional to the amount of sunlight it receives and its technological ability to convert it into usable energy. The higher the irradiance, the greater the short-circuit current, and vice versa. For this reason, a panel's performance is influenced by various factors, such as the time of year, the day, the region, and its geographical location (*Al Shehri et al, 2016*).

Box 2

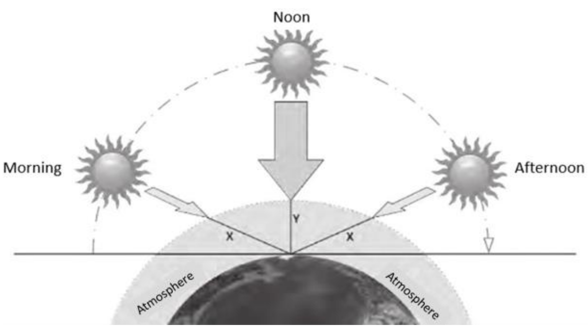


Figure 2
Variation in irradiance during the day
Source: Style, 2012

The optimal orientation for achieving the best performance of a photovoltaic installation is facing south when the location is in the northern hemisphere. Conversely, the panels should be oriented north when the installation is in the southern hemisphere.

For optimal tilt, the inclination should match the latitude of the installation site, which corresponds to the position of the area relative to the equator (north or south). To achieve this, the modules must be adjusted using the appropriate instruments (*Carta et al, 2009*).

A well-planned positioning involves placing the photovoltaic panel in a shadow-free area, orienting it toward the geographic south (or north in the southern hemisphere), and setting it at the appropriate inclination. To ensure that nearby objects do not cast shadows on the panel, it is essential to accurately calculate the lengths and directions of shadows. These calculations should be made with the winter solstice in mind, as this is the day when shadows are at their longest due to the sun's lowest path in the sky (*Carta et al, 2009*).

This work is divided into four sections. The first section provides a brief introduction, outlining the theoretical concepts relevant to the study.

Section 2 explains the methodology, detailing the equipment and procedures used in the experimental process, as well as specifying the techniques employed for measurement collection.

Section 3 presents the results of the analysis, illustrating the effects of solar incidence variation on the surface of the photovoltaic module. Finally, Section 4 includes the study's conclusions and inferences regarding the power generated by the module under different test conditions.

2. Methodology

The development of this experiment was carried out using a 410 W JaSolar photovoltaic module model JAM72S10 410/MR. A sensitive pyranometer (Kipp & Zonen) and a handheld pyranometer (Tenmars) were used for irradiance measurements. The measurement of the module's electrical parameters was carried out with a multimeter for solar panels.

This experiment was conducted using a 410 W JaSolar photovoltaic module, model JAM72S10 410/MR. For irradiance measurements, a sensitive pyranometer (Kipp & Zonen) and a handheld pyranometer (Tenmars) were employed. The electrical parameters of the module were measured using a multimeter specifically designed for solar panels.

To begin the experimental process, a large, shadow-free area was selected. The average irradiation for the region was then identified using the NASA Power platform, which provided the average Peak Sun Hours (PSH) for the city of Torreón, Coah. Figure 3 shows the location of the city on the map (25.54389°, -103.41898°), while Figure 4 displays the results obtained, highlighting the annual average PSH (6.34 hours).

Box 3

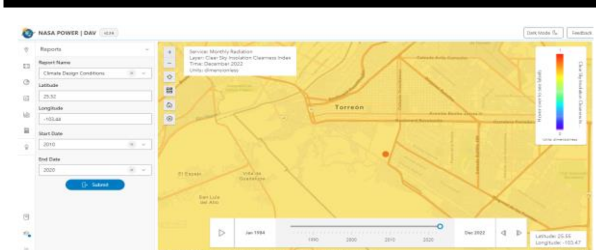
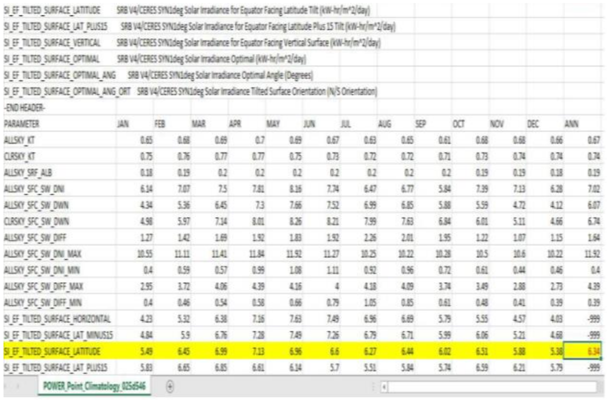


Figure 3
Location of Torreón, Coahuila
https://power.larc.nasa.gov

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

Box 4


SI_EF_TILTED_SURFACE_LATITUDE SRB V4/CERES SYN1deg Solar Irradiance for Equator Facing Latitude Tilt (kW-hr/m^2/day)
SI_EF_TILTED_SURFACE_LAT_PLUS15 SRB V4/CERES SYN1deg Solar Irradiance for Equator Facing Latitude Plus 15 Tilt (kW-hr/m^2/day)
SI_EF_TILTED_SURFACE_VERTICAL SRB V4/CERES SYN1deg Solar Irradiance for Equator Facing Vertical Surface (kW-hr/m^2/day)
SI_EF_TILTED_SURFACE_OPTIMAL SRB V4/CERES SYN1deg Solar Irradiance Optimal (kW-hr/m^2/day)
SI_EF_TILTED_SURFACE_OPTIMAL_ANG SRB V4/CERES SYN1deg Solar Irradiance Optimal Angle (Degrees)
SI_EF_TILTED_SURFACE_OPTIMAL_ANG_ORT SRB V4/CERES SYN1deg Solar Irradiance Tilted Surface Orientation (N/S Orientation)
-END HEADER-

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
ALLSKY_KT	0.65	0.68	0.69	0.7	0.69	0.67	0.63	0.65	0.61	0.68	0.68	0.66	0.67
CLRSKY_KT	0.75	0.76	0.77	0.77	0.75	0.73	0.72	0.72	0.71	0.73	0.74	0.74	0.74
ALLSKY_SRF_ALB	0.18	0.19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.19	0.19	0.18	0.19
ALLSKY_SFC_SW_DNI	6.14	7.07	7.5	7.81	8.16	7.74	6.47	6.77	5.84	7.39	7.13	6.28	7.02
ALLSKY_SFC_SW_DWN	4.34	5.36	6.45	7.3	7.66	7.52	6.99	6.85	5.88	5.59	4.72	4.12	6.07
CLRSKY_SFC_SW_DWN	4.98	5.97	7.14	8.01	8.26	8.21	7.99	7.63	6.84	6.01	5.11	4.66	6.74
ALLSKY_SFC_SW_DIFF	1.27	1.42	1.69	1.92	1.83	1.92	2.26	2.01	1.95	1.22	1.07	1.15	1.64
ALLSKY_SFC_SW_DNI_MAX	10.55	11.11	11.41	11.84	11.92	11.27	10.25	10.22	10.28	10.5	10.6	10.22	11.92
ALLSKY_SFC_SW_DNI_MIN	0.4	0.59	0.57	0.99	1.08	1.11	0.92	0.96	0.72	0.61	0.44	0.46	0.4
ALLSKY_SFC_SW_DIFF_MAX	2.95	3.72	4.06	4.39	4.16	4	4.18	4.09	3.74	3.49	2.88	2.73	4.39
ALLSKY_SFC_SW_DIFF_MIN	0.4	0.46	0.54	0.58	0.66	0.79	1.05	0.85	0.61	0.48	0.41	0.39	0.39
SI_EF_TILTED_SURFACE_HORIZONTAL	4.23	5.32	6.38	7.16	7.63	7.49	6.96	6.69	5.79	5.55	4.57	4.03	-999
SI_EF_TILTED_SURFACE_LAT_MINUS15	4.84	5.9	6.76	7.28	7.49	7.26	6.79	6.71	5.99	6.06	5.21	4.68	-999
SI_EF_TILTED_SURFACE_LATITUDE	5.49	6.45	6.99	7.13	6.96	6.6	6.27	6.44	6.02	6.51	5.88	5.38	6.34
SI_EF_TILTED_SURFACE_LAT_PLUS15	5.83	6.65	6.85	6.61	6.14	5.7	5.51	5.84	5.74	6.59	6.21	5.79	-999

POWER_Point_Climatology_025d546

Figure 4

Annual average of HSP in Torreón, Coahuila

https://power.larc.nasa.gov

Once the average PSH was determined, the first test involved measuring the irradiance in the area over time using both the sensitive pyranometer and the handheld pyranometer, as illustrated in Figure 5.

Box 5

Figure 5

Measurement of irradiance with sensitive pyranometer (Kipp & Zonen) and handheld pyranometer (Tenmars)

For the second test, the module's performance was analyzed based on its installation angle.

The photovoltaic module was oriented south, and its maximum power point was measured while varying the inclination angle from 10° to 45° in 5° intervals.

Figure 6 shows the module facing south at a 25° inclination, which corresponds to the latitude of the region.

Box 6

Figure 6

Location of the module in the photovoltaic test area

To evaluate the module's performance based on its orientation, the final test involved marking out a semicircular area, with angles in the azimuth plane ranging from east to west, passing through the south, in 15° intervals. This setup is shown in Figure 7.

Box 7

Figure 7

Marking of the azimuth plane

Finally, measurements of the module's electrical parameters were taken by varying both the inclination angle and its orientation in the azimuth plane.

This was made possible by using a structure specifically adapted to allow adjustments in both planes.

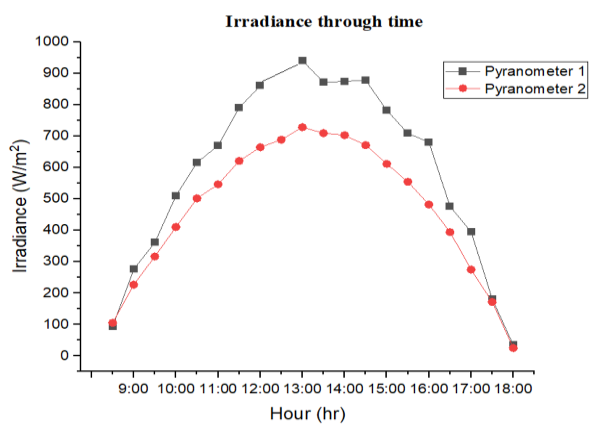
3. Results

In the first test, the curves obtained from measurements taken with each pyranometer were compared.

This comparison is illustrated in Graph 1, where "Pyranometer 1" refers to the Tenmars handheld pyranometer and "Pyranometer 2" refers to the sensitive Kipp & Zonen pyranometer.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

Box 8



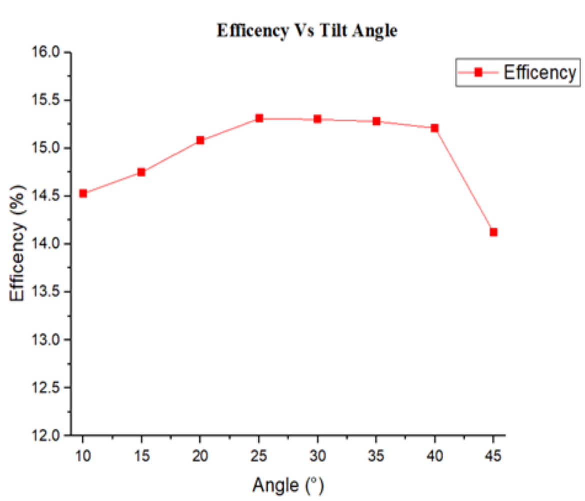
Graph 1
Irradiance over time

The difference in irradiance measurements between the two pyranometers is significant, as Pyranometer 1 has a sensitivity of 10 mW, while Pyranometer 2 has a sensitivity of 10 μW. However, the trends of the curves are consistent, indicating that around noon, which is typically close to the zenith, the highest levels of irradiance are recorded.

This observation confirms that peak solar hours occur around noon, when the sun's rays travel the shortest distance to reach the surface. In both cases, irradiance measurements exceeding 700 W/m² were obtained.

To understand the effect of the angle of solar incidence on the surface of the photovoltaic module, Graph 2 illustrates the efficiency generated by the module at various inclination angles.

Box 8

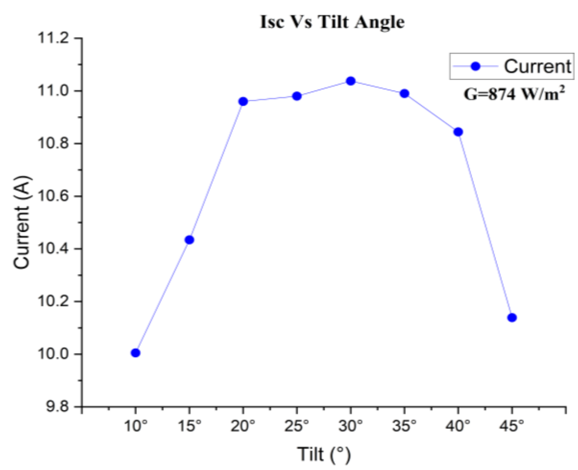


Graph 2
Efficiency of the module against the angle of inclination

From Graph 2, it can be observed that the highest efficiency from the module occurs at inclination angles between 25° and 35°. This aligns with the latitude of the test area, which is 25°. If the module's inclination is adjusted by more than 10° from this range, a decrease in photo generation occurs due to the adverse effects on the angle of solar incidence.

Similarly, Graph 3 illustrates the behavior of the short-circuit current (Isc) generated by the module in relation to the inclination angle, while the module received an average irradiance of 874 W/m².

Box 9



Graph 3
Short circuit current of the module against the angle of inclination

The generation of the short-circuit current in photovoltaic technology is directly dependent on the irradiance received by the PV modules on their surface; the greater the irradiance, the higher the current generated. In Figure 3, it is evident that the highest short-circuit current values occur at inclination angles between 20° and 35°.

In contrast, at other inclination angles, the short-circuit current decreases significantly. This phenomenon occurs because inclinations closer to the region's latitude enhance the reception of direct irradiance, allowing for more effective conversion of solar energy into electrical energy.

Through the third test, Table 1 presents the values of the maximum power point of the module at various orientations in the azimuth plane and different inclination angles.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

Castillo-Campos, Nohemí Alejandra, Palacio-Sifuentes, David Isaac, Escobedo-Márquez, Diana Laura and Álvarez Macías, Carlos. [2024]. Effect of the angle of solar irradiance on the photo generation of a photovoltaic module. ECORFAN-Journal Taiwan. 8 [15]1-7: e4815107.
https://doi.org/10.35429/EJT.2024.8.15.4.7

Box 10
Table 1
Power of the module according to orientation

(°)	Inclination							
γ_s	10	15	20	25	30	35	40	45
90	140	195	213	256	244	277	222	138
75	168	254	255	284	268	252	243	192
60	225	267	276	309	292	286	267	262
45	240	268	290	332	323	308	293	263
30	248	280	298	341	326	315	299	280
15	272	282	307	362	336	324	307	287
0	289	310	321	378	367	328	311	299
-15	183	231	282	351	321	313	307	229
-30	136	212	276	344	319	302	297	220
-45	156	165	228	325	311	267	252	145
-60	140	161	218	304	288	232	224	130
-75	94	135	213	289	268	202	152	89
-90	77	129	139	248	224	144	123	50

Source: Own elaboration

Table 1 highlights the value of 378 W, the maximum power output obtained from all measurements, achieved at an inclination of 25° with a direct orientation to the south (0° in the azimuth plane). This result confirms that this orientation is optimal for the region, as it aligns with the correct positioning for solar modules in the northern hemisphere.

Using the values in Table 1, it is possible to calculate the power loss factor corresponding to each orientation and inclination. The loss factor is determined using Equation 4.

$$Loss\ factor = \frac{Generated\ power}{Highest\ power\ measured} * 100 \qquad [4]$$

Table 2 shows the loss factor obtained for each measurement.

Box 11
Table 2
Loss factor according to orientation

(°)	Inclination							
γ_s	10	15	20	25	30	35	40	45
90	-6.2	-4.8	-4.3	-3.2	-3.5	-3.9	-4.1	-6.3
75	-5.5	-3.2	-3.2	-2.4	-2.9	-3.3	-3.5	-4.9
60	-4.0	-2.9	-2.6	-1.8	-2.2	-2.4	-2.9	-3.0
45	-3.6	-2.9	-2.3	-1.2	-1.4	-1.8	-2.2	-3.0
30	-3.4	-2.5	-2.1	-0.9	-1.3	-1.6	-2.0	-2.5
15	-2.7	-2.5	-1.8	-0.4	-1.1	-1.4	-1.8	-2.3
0	-2.3	-1.8	-1.5	0.0	-0.2	-1.3	-1.7	-2.0
-15	-5.1	-3.8	-2.5	-0.7	-1.4	-1.7	-1.8	-3.9
-30	-5.6	-4.3	-2.7	-0.9	-1.5	-2.0	-2.1	-4.1
-45	-5.8	-5.6	-3.9	-1.4	-1.7	-2.9	-3.3	-6.1
-60	-6.2	-5.7	-4.2	-1.9	-2.3	-3.8	-4.0	-6.5
-75	-7.4	-6.4	-4.3	-2.3	-2.9	-4.6	-5.9	-7.6
-90	-7.9	-6.5	-6.3	-3.4	-4.0	-6.1	-6.7	-8.6

Source: Own elaboration

Table 2 illustrates that to minimize the loss factor, the module should be oriented as closely to the south as possible, ideally within the range of -30° to +30°. Additionally, the inclination of the module should be maintained between 25° and 35°. Deviations from these angles tend to result in a higher power loss factor for the module.

4. Conclusions

In this work, research was carried out on the impact of the angle of solar incidence on the electrical parameters of a photovoltaic module. Through the analysis conducted, it was demonstrated that the optimal orientation of a photovoltaic module in the city of Torreón, Coahuila, is southward at 0° in the azimuth plane, with an inclination of 25°.

This configuration allows the surface of the PV module to align as closely as possible with the angle of solar incidence, thereby maximizing efficiency during peak solar hours, which occur around noon, with an average of 6.34 hours of peak sun.

The lowest power loss factor recorded was 0% at 25° inclination and 0° orientation, while the highest loss factor of -8.6% was observed at 45° inclination and -90° orientation.

This research can serve as a reference for other installations where the modules may not be positioned under the ideal conditions, providing insights into optimizing their performance even when perfect alignment is not achievable.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author Contribution

Castillo-Campos, Nohemí Alejandra: She contributed whit the project idea, bibliographic research, data collection and article writing.

Palacio-Sifuentes, David: He carried out the research method and technique, data collection and writing of the article.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

ECORFAN-Journal Taiwan 8[15]1-7: e4815107
Article

Escobedo-Marquez, Diana Laura: She contributed whit bibliographic research and article writing.

Alvarez-Macias, Carlos: He contributed to the supervision of the project, as well as the review and editing of the writing and verification of bibliography.

Availability of data and materials

The Hour Solar Pick of any region can be consulted at the NASA's web page; https://power.larc.nasa.gov/data-access-viewer/.

Funding

This work has been funded by CONAHCYT 1271718, 1305504 and 1188232; PRODEP 1188232.

Acknowledgements

The authors thank the support of CONAHCYT 1271718, 1305504 and 1188232; PRODEP 1188232.

Abbreviations

A	Amperes
G	Irradiance
HSP	Hour Solar Pick
I	Current
μW	Microwatts
mW	Milliwatts
Isc	Short Circuit Current
NASA	National Aeronautics and Space Administration
PV	Photovoltaic
W	Watts

References

Antecedents

Al Shehri A, Parrott B, Carrasco P, Al Saiari H, Taie I., "Impact of dust deposition and brush-based dry cleaning on glass transmittance for PV modules applications," Solar Energy, vol. 135, pp. 317-324, 2016.

Basics

Perpiñan Lamigueiro, O. (2007). Solar Radiation. In Photovoltaic solar energy, (Vol. 1, pp. 25–26). essay, Creative commons.

Montoya Rasero, C. (2011). Solar resource. In Photovoltaic Solar Energy (pp. 31–35). essay, School of Industrial Organization.

Marcial Alarcón, A. (2019). Solar Resource. In Photovoltaic Solar Energy (1st ed., pp. 12–13). essay, Elearning S. L.

Rodríguez Mas, F., Ruiz Gómez, A., & Valiente García, D. (2022). Solar radiation. In Notes on photovoltaic energy (p. 22). essay, Miguel Hernández University of Elche.

Style, O. (2012). The sun. In Autonomous Solar Energy: Planning, Dimensioning and Installation of an Autonomous Photovoltaic System (1st ed., pp. 15–16). essay, Ithaca.

Supports

Carta Gonzalez, J. A., Calero Pérez R., Colmenar Santos A., Castro Gil M-A. (2009). "Photovoltaic Solar Power Plants". In Centrales de Energías Renovables (pp. 248-255). essay, Pearson Education.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902