Energy Losses Caused by Different Azimuth Orientations and Tilt Angles in Photovoltaic Systems in Monterrey Nuevo León, Mexico

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Abstract: - Nuevo León is the second state in Mexico with the highest number of Distributed Generation (DG) projects, making it essential for companies implementing Photovoltaic (PV) Systems to understand the impact of proper orientation and tilt in their installations. This study was conducted using PVSyst V7.2.5, simulating conditions for Monterrey, Nuevo León, Mexico, with a reference project of 6.6 kWp and 6 kW AC at optimal azimuth and tilt angles, in order to benchmark energy losses. Additionally, a dataset was generated that includes energy loss values by azimuth orientation from -180° to 180°, combined with tilt angles corresponding to maximum and minimum solar altitude at 3° intervals for Monterrey. The results provide a reference framework and scientific contribution for the positioning of PV arrays by azimuth and tilt in DG projects in Monterrey, taking into account the associated energy losses for both engineering design and business planning in the companies involved.

Key-Words: - Renewable Energies, Photovoltaic Solar Energy, PVSyst V7.2.5, MATLAB, Energy Loss, Azimuth, Solar Altitude.

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1 Introduction

At the national level, according to the distributed generation statistics [1], [2], in 2023 the total installed capacity reached 3,361.69 MW, of which 64.39% corresponded to projects ranging from 0 to 50 kW. Furthermore, 411,085 interconnection contracts were issued, with 98.38% of these contracts assigned to projects within the same capacity range. This indicates that 404,322 contracts fall within this category, making it the most representative segment in terms of project distribution. Within this context, Nuevo León ranked second nationwide in 2023, with 46,818 interconnection contracts to the National Electric System and an installed capacity of 355.69 MW.

Based on this information, and considering that each photovoltaic project entails a set of losses that contribute to the total system performance, it is possible to break down and analyze these losses by their different causes. It is important to emphasize that companies developing solutions for reducing energy consumption in residential, commercial, or industrial sectors through PV system deployment must clearly understand the impact of proper orientation and tilt in their proposals and technical assessments. This ensures that end users, who invest financial resources in these projects, are provided with solutions that maximize the operational advantages and benefits that such technologies can deliver.

In line with these considerations, several studies in the literature address optimization, shading, and performance assessment in PV systems. A comprehensive review on PV optimization was presented in [3], covering 127 articles and emphasizing the necessity of optimization to ensure efficiency and minimize investment. Their findings highlight the importance of proper orientation and tilt angle in PV installations as key factors for economic benefits and business planning. Reconfiguration strategies were proposed in [4] to mitigate shading, showing additional revenues of $2689 and concluding that such approaches improve economic performance. These results reinforce the relevance of addressing azimuth and tilt angles as major loss factors directly related to profitability.

Shading and energy generation were analyzed in [5], concluding that installation geometry plays a crucial role in energy savings. Similarly, a shading reduction coefficient based on an anisotropic sky model was introduced in [6], underlining its importance in predicting system losses and supporting commercial decision-making. In tropical regions, AI-based optimization techniques were evaluated in [7], where it was demonstrated that ANFIS performs more effectively under non-uniform conditions, contributing to the goal of performance optimization and loss reduction.

Further studies have extended the analysis to hybrid technologies and simulation tools. Hybrid PVT systems were reviewed in [8], reporting an electrical efficiency of 10.4% and highlighting the relevance of design for overall performance and engineering contribution. PVsyst was used in [9] to evaluate shading and optimize the Performance Ratio (PR), obtaining a PR of 0.817 in one of the simulated designs, which directly reflects the impact of azimuth and tilt orientation on energy losses. Along similar lines, PVsyst was also employed in [10] for rooftop systems, reducing shading losses by 11–13% and achieving a PR of 0.791, further validating the tool's usefulness in quantifying energy losses. This approach was complemented in [11] with PV modeling and simulation, validating their model with only 1.65% error and confirming its robustness for evaluating PV system behavior.

Other contributions addressed the integration of PV into broader energy systems. Self-consumption and storage strategies were simulated in [12] using TRNSYS, concluding that such measures enhance grid stability and support renewable integration targets of up to 45%. PV performance issues were quantified in [13], including fault masking, through duration curve analysis, stressing the need for common metrics to assess availability and system losses. Finally, compensation mechanisms for residential PV were analyzed in [14], showing high NPV and confirming the economic viability of shared net metering schemes, directly linking PV adoption with business planning and economic benefits.

Based on the national and regional context and considering the evidence from the literature on PV optimization, shading, and system performance, this study focuses specifically on the analysis of two critical loss factors: azimuth and tilt. By examining these parameters in the Monterrey Metropolitan Area, the present work aims to quantify their impact on system performance, identify optimal configurations, and provide practical guidance for PV project design and implementation within the scope of distributed generation. This focus ensures that the results are directly applicable to both technical planning and decision-making for residential, commercial, and industrial PV deployments.

2 Methodology

2.1 Simulation of the PV System using PVsyst 7.2.5

A grid-connected photovoltaic (PV) system was simulated using PVsyst 7.2.5. The reference project was defined with a nominal power of 6 kW in alternating current (AC) and 6.6 kWp in direct current (DC). The selected PV module was the 550 Wp LR5-72 HPH 550 M [15], manufactured in 2021, and the inverter chosen was the Solis-1P6K2-4G-US [16]. To ensure model accuracy, the Perez-Perez model was used for irradiance transposition, while Meteonorm was employed for irradiance decomposition.

The simulation environment incorporated detailed technical parameters to reflect real-world operating conditions:

System Losses: Parameters included a 3.0% soiling loss, 2.0% light-induced degradation (LID), 2.0% mismatch losses, and 2.0% system unavailability.

Wiring: Ohmic losses were set at 1.5% at STC for the DC side (with a global resistance of 140 mΩ) and 2.48% for the AC side.

Temperature Model: Thermal loss coefficients of Uc = 29.0 W/m²K and Uv = 0.0 W/m²K/m/s were applied.

Inverter Assumptions: Inverter loss during operation was calculated at 3.23% based on its specific efficiency curve.

The simulation inputs included an optimal tilt of 26° and an azimuth of 0°, serving as the benchmark case. A response graph was developed with azimuth values ranging from 0° to ±180° in 10° steps, combined with tilt angles in 3° increments up to 50°. These increments were selected to achieve a balance between adequate spatial resolution for identifying regional trends and computational efficiency, as the combination of these steps generated a database of over 600 simulation points. While these steps accurately capture the "optimal configuration zone", the use of smaller steps would allow for greater mathematical precision, as suggested in the study's recommendations. Finally, information was cross-checked to identify the loss relationship due to tilt and orientation versus generated energy.

3 Cosine Loss Analysis using MATLAB

A complementary study was performed in MATLAB to calculate cosine losses, considering only the direct incident energy on the photovoltaic (PV) module.

The analysis covered the same azimuth and tilt domain as the PVSyst simulations, ranging from -180° to +180° in azimuthal orientation (10° steps) and 0° to 50° in tilt (3° steps). The objective was to define a decision parameter capable of identifying the orientation and tilt yielding maximum energy capture. While the method is restricted to direct irradiance, it provides a sufficiently robust indicator for comparison with full-system performance simulations.

Solar positions were computed hourly across the entire year using a Typical Meteorological Year (TMY) dataset from Meteonorm. By combining the solar position with the orientation of the tilted plane, the incidence angle of the incoming radiation can be accurately determined.

Mathematically, this is achieved by defining a Cartesian coordinate system where the X-axis points South, meaning the azimuth is 0° at solar noon, negative during the morning (East), and positive in the afternoon (West). It is necessary to know the position of the sun, characterized by a unit vector $\left(\hat{S}\right)$ that is defined by Equation 1 [17], where, γ_s represents the solar azimuth angle and, α_s the solar altitude angle.

$$\hat{S} = \begin{pmatrix} S_x \\ S_y \\ S_z \end{pmatrix} = \begin{pmatrix} \cos\alpha_s \cos\gamma_s \\ \cos\alpha_s \sin\gamma_s \\ \cos\alpha_s \end{pmatrix} \quad (1)$$

Equation 2 defines the panel's normal vector $\left(\widehat{N}\right)$, which is a function of the tilt angle (β) its azimuth orientation $\left(\gamma_p\right)$.

$$\widehat{N} = \begin{pmatrix} N_x \\ N_y \\ N_z \end{pmatrix} = \begin{pmatrix} \sin\beta \cos\gamma_p \\ \sin\beta \sin\gamma_p \\ \cos\beta \end{pmatrix} \quad (2)$$

The cosine of the incidence angle (θ), which represents the cosine loss factor, is obtained by computing the dot product of these two vectors, since both vectors are unitary (see Eq. 3).

$$\cos\theta = \hat{S} \cdot \widehat{N} \quad (3)$$

This mathematical formulation accurately determines the deviation between the incident solar rays and the module's surface, establishing the exact basis for the direct irradiance losses evaluated in the MATLAB algorithm.

While Equation 3 defines the instantaneous cosine loss factor, evaluating the overall system performance requires an annualized approach. To achieve this, a simulation algorithm was developed in MATLAB based on the sequential process shown in Figure 1.

First, the Typical Meteorological Year (TMY) dataset was utilized to provide hourly direct irradiance and solar position data (α, γ) for Monterrey. Second, a computational domain was defined for the photovoltaic array's spatial configuration, varying the panel azimuth (γ_p) from -180° to 180° in 10° increments, and the tilt angle (β) incrementally from 0° up to 50°.

For each specific azimuth-tilt combination, the algorithm iterates through the 8,760 hours of the year. At every hourly step, the instantaneous cosine loss factor is calculated and multiplied by the available direct irradiance of that specific hour. These hourly energy values are then integrated to calculate the total annual direct energy captured for that particular (γ_p, β) pair.

This iterative process generates a comprehensive matrix of annual energy values. From this matrix, the absolute maximum energy yield is identified, establishing the optimal reference configuration. Finally, the relative percentage of energy loss caused by different orientations and tilt angles is calculated for every point in the matrix by comparing its annual yield against this optimal reference. This methodology results in the generation of the annualized cosine loss map.

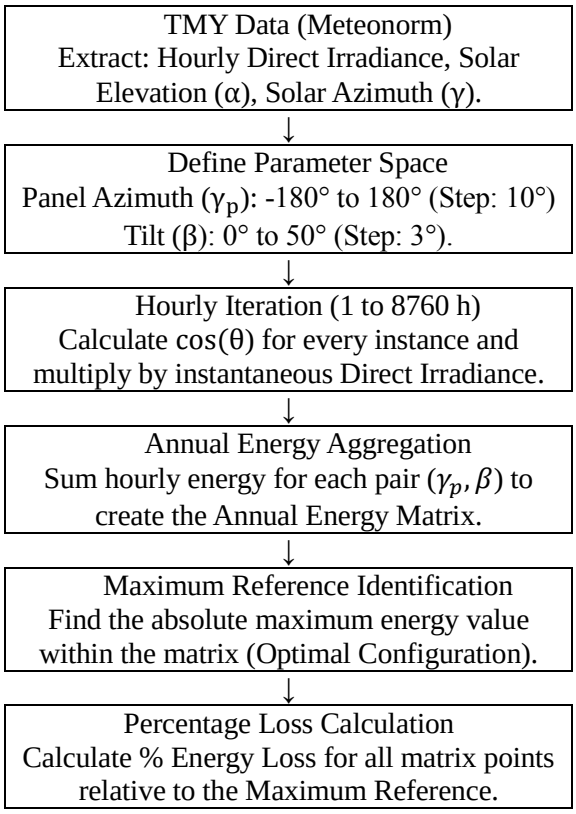


Fig. 1: Flowchart of the MATLAB simulation algorithm for annualized cosine loss calculation
Source: Created for the authors

4 Results

The reference simulation was carried out in PVsyst 7.2.5 using geolocation data for Monterrey, Nuevo León, Mexico (Figure 2), together with meteorological inputs of irradiance and temperature obtained from Meteonorm 8.0 for the period 2000–2009 (Table 1). The meteorological data presented is synthetic in nature and represents a Typical Meteorological Year (TMY) for Monterrey. This dataset is critical for the study's representativeness, as it aggregates decade-long averages to filter out inter-annual weather variability. Consequently, the irradiance and temperature patterns documented serve as a stable regional baseline, ensuring that the simulated energy losses reflect long-term performance trends rather than short-term environmental anomalies. The solar trajectory for the study site is illustrated in Figure 3, while the optimal tilt and orientation of the PV array are presented in Figure 4. In addition, Figure 5 shows the nearby shading parameters considered in the analysis, which contribute to the overall system performance evaluation.

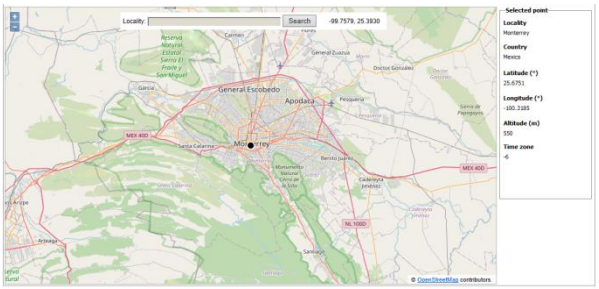


Fig. 2: Geolocation for the reference project analysis
Source: Generated by the authors using PVSyst V7.2.5.

Table 1. Irradiance and Temperature Data (Meteonorm 8.0, 2000–2009)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	
Horizontal global	3.50	4.40	5.29	5.91	6.24	6.78	6.42	6.23	5.25	4.94	4.22	3.34	5.21	kWh/m²/day
Horizontal diffuse	1.56	1.65	1.94	2.28	2.43	2.74	2.67	2.28	2.34	1.80	1.33	1.46	2.04	kWh/m²/day
Extraterrestrial	6.64	7.88	9.22	10.41	11.06	11.27	11.15	10.66	9.68	8.34	6.98	6.26	9.13	kWh/m²/day
Clearness Index	0.527	0.558	0.574	0.568	0.564	0.602	0.575	0.585	0.542	0.592	0.604	0.533	0.571	ratio
Ambient Temper.	15.5	17.8	21.2	24.3	27.1	28.7	29.0	29.3	26.3	23.5	18.7	15.8	23.1	°C
Wind Velocity	2.1	2.3	2.5	2.6	2.6	2.9	2.7	2.6	2.1	2.1	1.9	2.0	2.4	m/s

Source: *Generated by the authors using Meteonorm 8.0 and PVSyst V7.2.5, with data exported via PVSyst.*

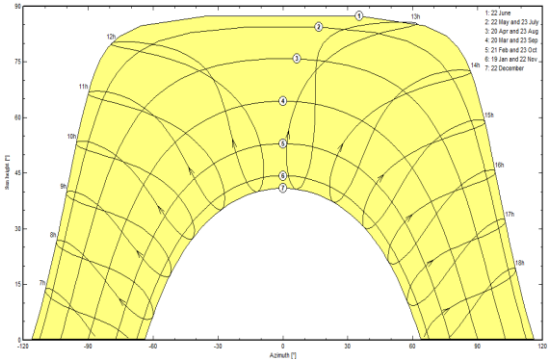


Fig. 3: Solar Path in Monterrey, Nuevo León, Mexico
Source: Generated by the authors using PVSyst V7.2.5.

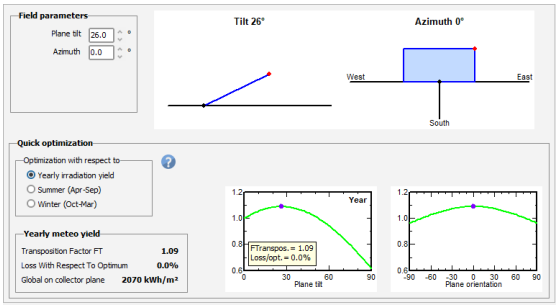


Fig. 4: Optimal Tilt and Orientation of the PV Array in Monterrey, Nuevo León, Mexico
Source: Generated by the authors using PVSyst V7.2.5.

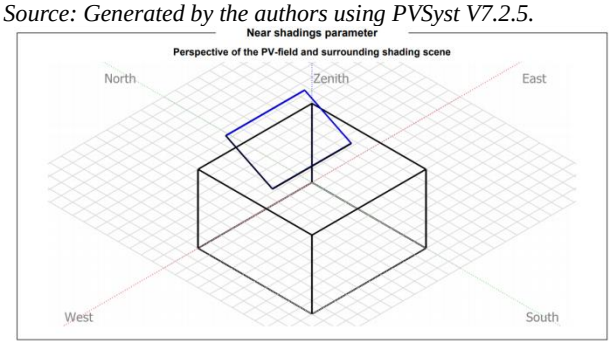


Fig. 5: Near Shading Parameters
Source: Generated by the authors using PVSyst V7.2.5.

From this, the Iso-Shading diagram for the PV array at optimal orientation in Monterrey, Nuevo León, Mexico was obtained (Figure 6). After analysis, it was identified that there are no losses due to the optimal tilt and azimuth (26° tilt and 0° azimuth) or from objects causing partial shading. The system exhibits a performance ratio of 75.24%, as shown in the Results summary (Table 2).

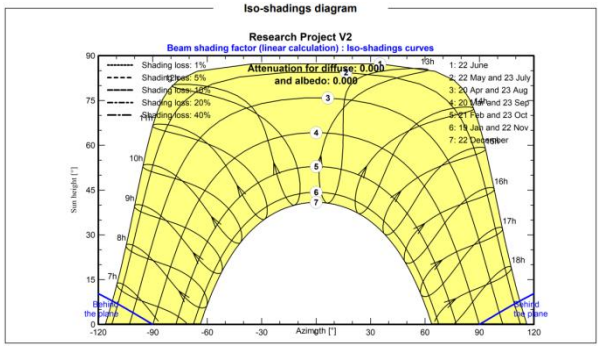


Fig. 6: Iso-Shading Diagram at Optimal PV Array Orientation in Monterrey, Nuevo León, Mexico
Source: Generated by the authors using PVSyst V7.2.5.

Table 2. Project summary

Project summary

Geographical Site		**Situation**		**Project settings**	
Monterrey		Latitude	25.68 °N	Albedo	0.20
Mexico		Longitude	-100.32 °W		
		Altitude	550 m		
		Time zone	UTC-6		
Meteo data					
Monterrey					
Meteonorm 8.0 (2000-2009), Sat=53% - Sintético					

System summary

Grid-Connected System		**Tablas en un edificio**			
Simulation for year no 10					
PV Field Orientation		**Near Shadings**		**User's needs**	
Fixed plane		Linear shadings		Unlimited load (grid)	
Tilt/Azimuth	26 / 0 °				
System information					
PV Array		**Inverters**			
Nb. of modules	12 units	Nb. of units	1 Unit		
Pnom total	6.60 kWp	Pnom total	6.00 kWac		
		Pnom ratio	1.100		

Results summary

Produced Energy	10.18 MWh/year	Specific production	1542 kWh/kWp/year	Perf. Ratio PR	75.58 %

Source: Generated by the authors using PVSyst V7.2.5.

Table 2 defines the technical boundary conditions of the reference project, establishing a system with 6.6 kWp in DC and 6 kW in AC. The numerical significance of this summary lies in its scalability; by fixing the module and inverter parameters under optimal conditions (26° tilt, 0° azimuth), the study provides a controlled framework. This allows for the subsequent isolation of angular loss factors, making the results applicable as a standardized tool for regional engineering and business planning

For the development of the graph, azimuth values from 0° to -180° (i.e., south to north passing through east) and from 0° to 180° (i.e., south to north passing through west) were considered, with a step of 10° for each data point, covering the full 360° of potential PV array orientation. This includes the possibility of north-facing orientations in our geographic area, which, although unlikely, can occur due to obstacles or the various conditions of rooftops in the Monterrey metropolitan area, where buildings (residential, commercial, or industrial) were not designed to integrate photovoltaic technology for electricity consumption reduction.

Each azimuth value at 10° intervals was combined with tilt angles starting at 0°, 2°, and then increasing by 3° increments up to 50°, including the maximum tilt for the geolocation of Monterrey (25.6640425, -100.2431621), which is 41°, [18]. This resulted in Figure 7 (Percentage of losses according to tilt from 0° to 50° and azimuth shift from -180° to 180°, based on data from the PVsyst simulator).

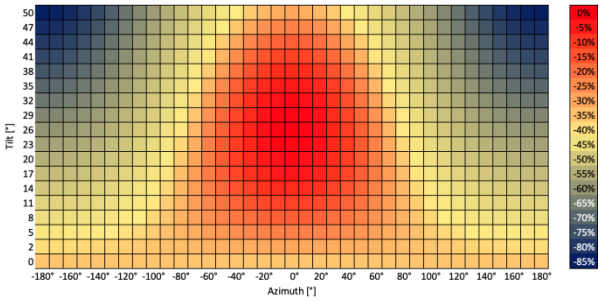


Fig. 7: Percentage loss as a function of tilt (0º–50º) and azimuth deviation (-180º to 180º) based on PVsyst simulation data
Source: Generated by the authors using PVSyst V7.2.5.

The obtained tables characterize the loss behavior and provide the necessary values to optimize the tilt and orientation of PV arrays in the Monterrey Metropolitan Area, which is achieved with a 26° tilt and 0° azimuth. Furthermore, azimuthal losses remain below or equal to 1% under several configurations: for tilts between 17° and 23° and between 29° and 35° at 0° azimuth; for tilts between 20° and 32° with an azimuth of ±10° (rotated 10° east or west); and for tilts between 20° and 29° with an azimuth of ±20° (rotated 20° east or west).

The calculated loss values were compared in a test simulation using an 8° tilt and 20° west azimuth (Figure 8), and then benchmarked against the reference simulation with the optimal 26° tilt and 0° azimuth (Figure 9).

A critical analytical insight derived from Table 3 (Appendix) is the discrepancy between system efficiency and absolute energy delivery. While the absolute production suffered a 3.48% reduction in the test case, the Performance Ratio (PR) remained virtually constant with an insignificant 0.08%

deviation (75.44% vs. 75.36%). Physically, this indicates that non-optimal orientation does not degrade the internal health or conversion efficiency of the modules and inverter. Instead, the angular deviation acts as a direct limiter of the energy availability at the source (the irradiance on the plane). For business planning, this distinction is vital: a non-optimally oriented system is not 'inefficient' in its operation, but it is effectively 'undersized' in its total contribution to the grid.

The visual symmetry observed in Figure 7 and Figure 10 confirms that energy losses are independent of the orientation direction (East or West) in the absence of external shading. More importantly, the central region of these maps defines an 'optimal tolerance zone' where energy production remains within 99% of its theoretical maximum.

This zone—spanning azimuths of ±20∘ and tilts between 20° and 29°—indicates that the system is resilient to minor angular deviations. From a physical standpoint, this provides critical architectural flexibility for urban PV deployments in Monterrey, as rooftops rarely align perfectly with the true South, yet can still achieve near-optimal yields without the need for expensive structural corrections.

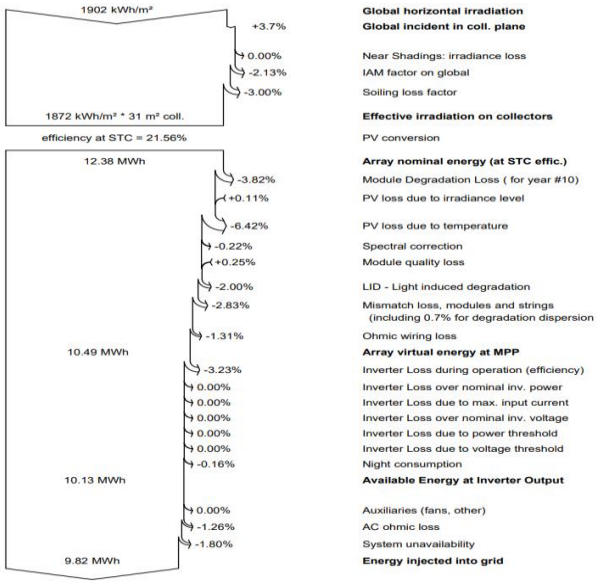


Fig. 8: Loss Diagram at Azimuth 20° and 8° Tilt of the PV Array in Monterrey, Nuevo León, Mexico
Source: Generated by the authors using PVSyst V7.2.5.

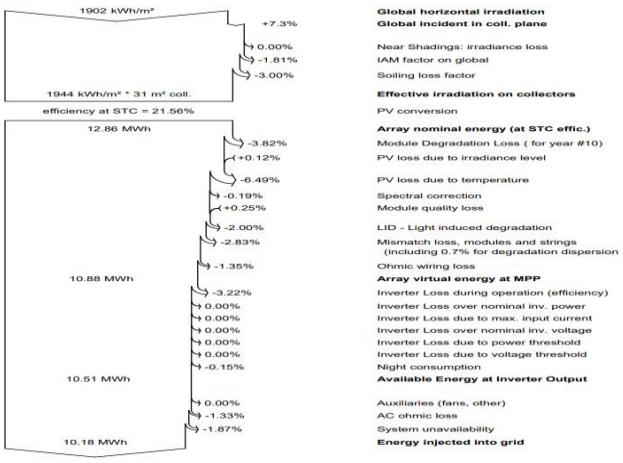


Fig. 9: Loss Diagram at Azimuth 0° and 26° Tilt of the PV Array in Monterrey, Nuevo León, Mexico
Source: created by the authors using PVSyst V7.2.5.

From the cosine loss analysis performed in MATLAB, an analogous graph to that presented in Figure 7 was obtained. This graph exhibits a loss pattern comparable to that observed in the PVsyst simulations (Figure 10), while maintaining the same loss scale. Such consistency validates the general trend of orientation- and tilt-induced losses and reinforces the conclusions regarding the optimal configuration zone identified in the main study.

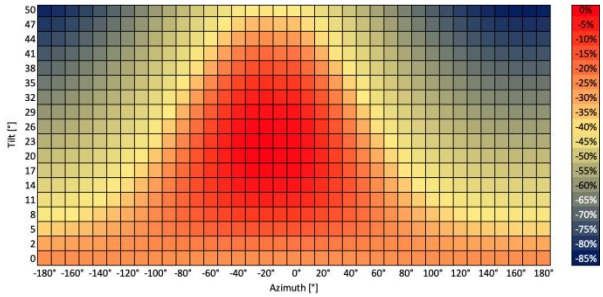


Fig. 10: Percentage loss as a function of tilt (0º–50º) and azimuth deviation (-180º to 180º) based on MATLAB calculation data
Source: Generated by the authors using the mathematical model presented in Eqs. (1)–(3).

5 Conclusion

This study provides the first regionalized reference framework for the implementation of Distributed Generation (DG) projects in the Monterrey Metropolitan Area, Nuevo León. The results demonstrate that while the optimal configuration is achieved with a 26° tilt and 0° azimuth, there is an optimal tolerance zone where orientation-induced losses remain within an acceptable range of ≤1%. This zone includes tilts from 20° to 29° with azimuth deviations of up to ±20∘, offering technical flexibility for rooftop designs with architectural

constraints without significantly compromising financial viability.

A critical finding of this analysis is the distinction between the Performance Ratio (PR) and energy yield. While the comparison between the optimal case and the test case (8° tilt and 20° azimuth) showed an insignificant 0.08% deviation in PR (75.44% vs. 75.36%), the absolute energy production suffered a 3.48% reduction. This highlights that non-optimal orientation directly impacts the total energy injected into the grid and the return on investment, even if the system maintains its internal operating efficiency.

The 15.12% discrepancy found between the observed production loss (3.48%) and the calculated loss in the parametric map (4.10%) is justified through the analysis of the loss diagram (Sankey). Tilt and azimuth effects should not be assessed as isolated data points, but rather as part of an integrated system where non-linear variables—such as inverter efficiency (3.23%) and temperature losses (~6.4%)—interact annually to dampen the impact of pure angular deviation.

6 Limitations

This study is based on computer simulations validated through the consistency between PVsyst and MATLAB, representing a robust baseline for planning. However, the analysis identifies external loss factors beyond orientation that are critical in northeastern Mexico, such as soiling (3.0%), light-induced degradation (LID) (2.0%), and thermal variations. Furthermore, the simplified MATLAB model was restricted to direct radiation, omitting the diffuse and albedo components that PVsyst integrates, which partially compensate for cosine losses under real sky conditions

7 Recommendations

It is advisable to perform a more detailed analysis with smaller angular steps in order to obtain greater precision regarding the potential energy losses of the photovoltaic system.

8 Final Remarks

The information generated in this study serves as a robust decision-making tool for the 46,818 companies and users in Nuevo León with interconnection contracts. Consequently, future work will incorporate a detailed economic impact analysis and utilize smaller angular steps in simulations to further refine the precision of the identified optimal tolerance zone. Furthermore, future research will aim to validate these simulated results against real-world system data from local installations in Monterrey. Finally, the study will be expanded to include advanced quantitative evaluation methods, such as uncertainty quantification and error analysis of the meteorological datasets, to further strengthen the reliability and scientific rigor of the simulated performance results.

Author Contributions: J-Emmanuel Bautista Salazar: Conceptualization, Methodology, Software (PVsyst simulation), and Writing – Original Draft. José Alberto Duarte Moller: Supervision, Project Administration, and Writing – Review & Editing. Héctor Daniel García Lara: Methodology (Mathematical model for cosine loss and MATLAB simulation), Formal Analysis, and Writing – Review & Editing. Miguel Ángel Ochoa Villegas: Validation, Resources, and Writing – Review & Editing.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author(s) utilized artificial intelligence (AI) technologies solely for the purpose of linguistic refinement and grammatical correction. Following the application of these tools, the author(s) comprehensively reviewed, verified, and edited the resulting text. The author(s) maintain full accountability and responsibility for the accuracy, integrity, and final content of the publication.

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APPENDIX

Table 3. Comparison of Performance Ratio (PR) for each case with different tilt and orientation values

	Az0º@26°	Az20º@8º
Global horizontal irradiation incident on receiving plane	7.3%	3.70%
Global IAM factor	-1.81%	-2.13%
Soiling loss factor	-3%	-3%
Efficiency at STC	21.56%	21.56%
Module degradation loss (per year #10)	-3.82%	-3.82%
PV loss due to irradiance level	0.12%	0.11%
PV loss due to temperature	-6.49%	-6.42%
Spectral correction	-0.19%	-0.22%
Module quality loss	0.25%	0.25%
Module quality loss	-2%	-2%
Mismatch losses, module and strings (including 0.9% due to degradation dispersion)	-2.83%	-2.83%
Ohmic wiring loss	-1.35%	-1.31%
Inverter loss during operation (efficiency)	-3.22%	-3.23%
Nighttime consumption	-0.15%	-0.16%
AC ohmic losses	-1.33%	-1.26%
System unavailability	-1.87%	-1.80%
Total	0.0117	-0.0256
	100.01	**99.97**
PR	**75.58**	**75.49**
	24.43%	**24.48%**
Annual Production MWh:	10.180	9.82
Loss due to orientation change	**0%**	**3.54%**

Source: Generated by the authors using Microsoft Excel.

Nomenclature and Abbreviations

Category	Abbreviation	Meaning
General & Regulatory	CRE	Energy Regulatory Commission
	DG	Distributed Generation
	PV	Photovoltaic
	TMY	Typical Meteorological Year
	UTC	Coordinated Universal Time
Units of Measurement	kW / kWp	Kilowatt / Kilowatt-peak
	kWh / MWh	Kilowatt-hour / Megawatt-hour
	MW	Megawatt
Meteorological Data	DiffHor	Diffuse Horizontal Irradiance
	GlobHor	Global Horizontal Irradiance
	GlobInc	Global Incident Irradiance
	GlobEff	Global Effective Irradiance (corrected for IAM)
	T_Amb	Ambient Temperature
System Performance	AC / DC	Alternating Current / Direct Current
	E_Grid	Energy Injected into the Grid
	EArray	Effective Energy at the Output of PV Array
	IAM	Incidence Angle Modifier
	LID	Light-Induced Degradation
	MPPT	Maximum Power Point Tracking
	PR	Performance Ratio
	STC	Standard Test Conditions
Mathematical / AI	ANFIS	Adaptive Neuro-Fuzzy Inference System
	NPV	Net Present Value
	RMS	Root Mean Square

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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