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LATITUDINAL ASSESSMENT OF ROOFTOP BIFACIAL PV IRRADIANCE ACROSS MEXICO USING BIFACIAL RADIANCE

Summary

Bifacial rooftop PV performance is influenced by solar geometry, which varies with latitude; however, distributed-generation rooftops are rarely assessed systematically across latitudinal ranges. This work presents preliminary Radiance based simulations using Bifacial Radiance for four representative Mexican latitude labels (15°, 20°, 25°, 30°N) using EPW files from Tuxtla, Mexico City, Monterrey, and Hermosillo. A constant south-facing rooftop layout was used (azimuth 180°, roof reflectance ρ=0.70, clearance 0.60 m, pitch 4.0 m, 2 rows × 6 modules) and evaluated under representative snapshots (equinox and winter solstice; late morning and early afternoon). Mean front and rear plane-of-array irradiance and the rear to front ratio $R = \bar{G}_{rear}/\bar{G}_{front}$ were computed and averaged over snapshots. The rear contribution varied across latitude labels, with average R values spanning 0.3167–0.3790. These preliminary results highlight the need for latitude-aware bifacial rooftop assessment to inform improved design practices and maximize irradiance capture and electrical generation.

Field of application for the findings: Distributed generation rooftop PV design; bifacial irradiance assessment across Mexico's latitudinal span.

Addressed audience: Researchers and practitioners in PV modelling, rooftop PV design, and solar resource assessment.

1. Introduction

Bifacial photovoltaic (PV) technology can generate electricity not only from the irradiance incident on the front side of the module (direct and diffuse), but also from the fraction reflected by the surroundings (albedo) that reaches the rear side [1]. This dual collection makes it an attractive option to increase energy yield and improve the levelized cost of energy (LCOE), particularly in distributed generation schemes where available area is usually limited [2]. In recent years, its adoption has grown due to the potential for additional energy gains; however, this benefit is neither fixed nor straightforward to estimate, since rear-side contribution depends on multiple factors such as module height, tilt angle, surface reflectance, array geometry, solar elevation, and the diffuse component, among other site specific variables [3]. Therefore, common design practices inherited from monofacial systems (e.g., setting the tilt "equal to latitude") do not necessarily lead to optimal performance for bifacial PV. This study focuses on assessing the effect of latitude and tilt angle on energy generation, using radiative simulation to quantify irradiance on both sides of the module [4]. Specifically, Bifacial Radiance, a ray tracing based tool, is employed to compare representative scenarios and highlight the need to account for these considerations in residential/urban distributed-generation applications, a context that has been less addressed than utility scale projects.

2. Methodology

Simulations were performed using a Radiance-based workflow implemented in Bifacial Radiance with Typical Meteorological Year EPW files from four representative locations used as latitude labels: Tuxtla (15°N), Mexico City (20°N), Monterrey (25°N), and Hermosillo (30°N). A simplified south-facing rooftop bifacial PV configuration was modeled with fixed geometry across all cases to isolate latitudinal influence: azimuth 180°, roof modeled as a flat reflective plane with constant reflectance ρ = 0.70 (white roof waterproofing), clearance height 0.60 m, row pitch 4.0 m, and an array of 2 rows × 6 modules (generic commercial module geometry ~1.1 m × 2.0 m). Two tilt approaches were evaluated: TFIX, a fixed practical module tilt of 15° for all locations, and TLAT, a latitude based tilt where the module tilt equals the corresponding latitude label (15°, 20°, 25°, 30°). For each location, representative snapshot conditions were evaluated (equinox and winter solstice; late morning and early afternoon). Outputs were post-processed to obtain mean front and rear plane-of-array irradiance and the rear-to-front ratio (eq. 1), reported as averages over the simulated snapshots.

$$R = G_{rear}/G_{front} \quad \text{(eq. 1)}$$

3. Preliminary results

Figure 1 presents the mean rear/front ratio across latitude labels for both tilt strategies, while Table 1 reports the corresponding mean front and rear irradiance values used to compute the ratio. Averaged over the evaluated snapshots, the rear/front ratio spans from 0.3167 to 0.3790 (Table 1). The fixed-tilt baseline (TFIX = 15°) remains relatively stable between 15–25°N (0.342–0.348) and increases at 30°N (0.3790). In contrast, TLAT shows a decreasing trend from 0.3469 (15°N) down to 0.3167 (30°N) (Figure 1). At 30°N, TFIX yields higher mean rear irradiance (205.87 W/m²) than TLAT (188.95 W/m²) despite TLAT using a larger tilt (Table 1), suggesting that tilt ≈ latitude does not necessarily maximize rear side contribution for rooftop bifacial PV under fixed geometric constraints.

Table 1. Mean front and rear plane-of-array irradiance and rear/front ratio by latitude label and tilt strategy (averaged over snapshots).

Table 1. Mean front and rear plane-of-array irradiance and rear/front ratio by latitude label and tilt strategy (averaged over snapshots).

Latitude label (°N)	**Strategy**	**Tilt (°)**	**Front mean (W/m²)**	**Rear mean (W/m²)**	**Ratio (–)**
15	TFIX	15	778.70	270.26	0.3471
15	TLAT	15	788.19	273.43	0.3469
20	TFIX	15	723.25	251.64	0.3479
20	TLAT	20	724.32	240.39	0.3317
25	TFIX	15	666.29	228.01	0.3422
25	TLAT	25	682.38	223.40	0.3274
30	TFIX	15	543.20	205.87	0.3790
30	TLAT	30	596.62	188.95	0.3167

Table 1 provides the averaged front and rear plane-of-array irradiance values used to compute R, showing how both components change across locations. While front irradiance decreases toward higher latitude labels under the evaluated snapshots, rear irradiance exhibits a different response, which explains the changes observed in $R$and supports the need for latitude-aware rooftop bifacial assessment.

Figure 1. Mean rear to front irradiance ratio (averaged over representative snapshots) across four Mexican latitude labels, comparing TFIX (15° fixed tilt) and TLAT (tilt ≈ latitude).

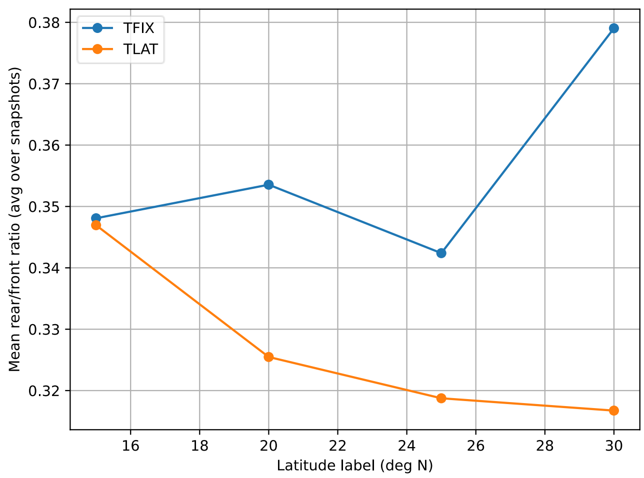

Fig. 1 Mean rear-to-front irradiance ratio (averaged over representative snapshots) across four Mexican latitude labels, comparing TFIX (15° fixed tilt) and TLAT (tilt ≈ latitude).

Figure 1 shows that the mean rear-to-front ratiovaries with latitude label under the fixed rooftop assumptions, indicating a latitudinal influence on rear-side contribution. The two tilt approaches follow different trends across the evaluated range, which highlights that tilt selection can modify the rear/front balance even when all other geometric parameters are kept constant.

4. Preliminary conclusions

These preliminary results confirm a measurable latitudinal influence on rooftop bifacial irradiance conditions under fixed geometry and roof reflectance assumptions, with a non-negligible rear-side contribution (average $R = \bar{G}_{rear}/\bar{G}_{front}$on the order of 0.32–0.38 across the evaluated cases). The observed variability across representative locations suggests that rooftop bifacial performance should not be generalized from a single site or from utility-scale assumptions, motivating latitude-aware evaluation as a basis for improved design practices aimed at maximizing irradiance capture and, consequently, electrical generation. Future work will expand temporal coverage and assess additional rooftop parameters (e.g., reflectance scenarios and spacing/clearance sensitivity) to support more robust best-practice recommendations.

5. References

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