Comparison of Bifacial Solar Irradiance Model Predictions with Field Validation

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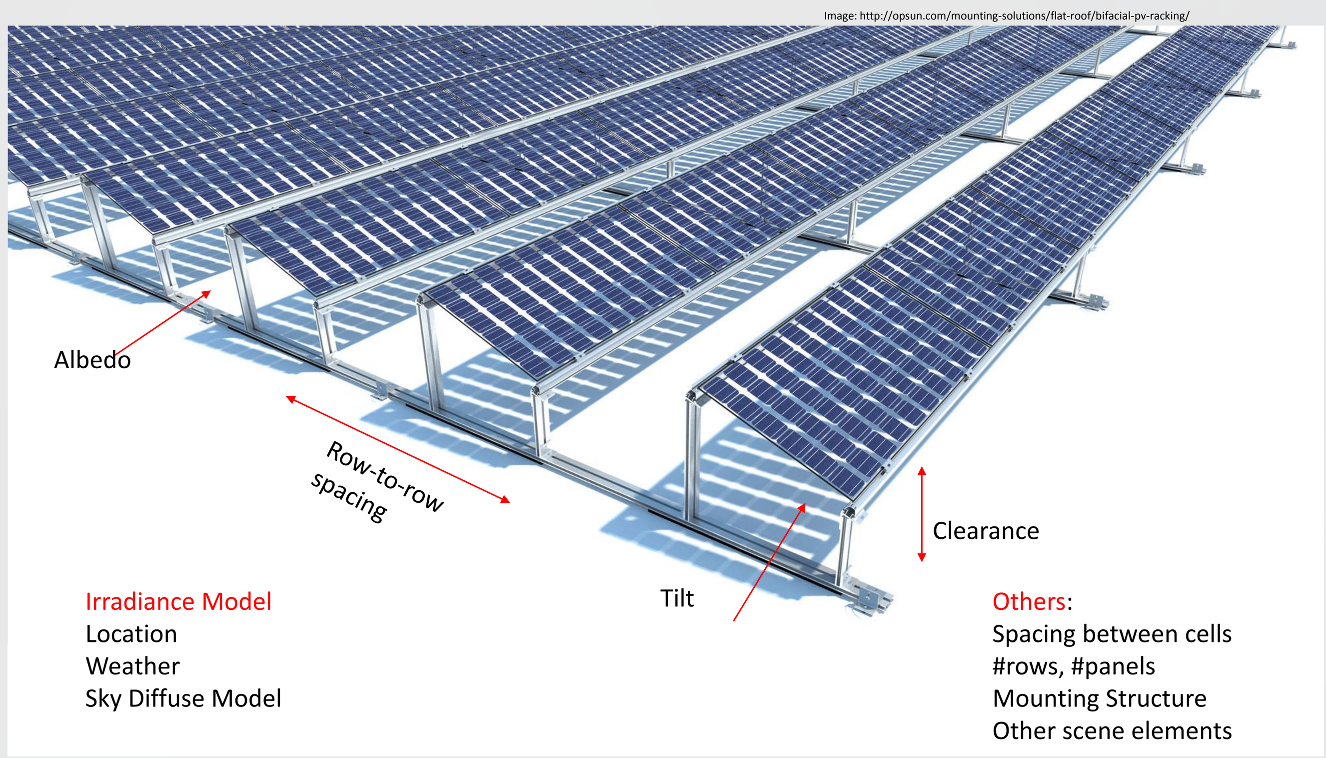
10th PVPMC

Introduction

Bifacial panels collect light from both sides. Their market share projections reach 30% by 2027[1]



Models predicting rear irradiance for bifacial systems are critical to establish accurate estimates of energy yield.

Here we compare five published bifacial optical models, varying:

- clearance
- row spacing
- tilt
- albedo

Materials and Methods

Bifacial system performance models utilize different methods to calculate the rear irradiance:

More complexity →

empirical | **view factor** | **raytrace**

Quantity	Prism Solar	Solar World	PV Syst	NREL VF	Radiance
Albedo, tilt, h, gcr	✓[1]	✓	✓	✓	✓
Panel Size	X[2]	✓[3]	✓	✓[3]	✓
BG_E Calculated	By year	By year	By Hour	By Hour	By year
Running time for yearly simulation[4]	<1s	<1s	<10s	<10s	<60s
Irradiance Profiles	-	-	?	✓	✓
Ground incident irradiance model	-	-	✓[5]	✓[6]	✓[6]
Glass-air transmission loss	-	-	?	✓[7]	-
Light transmitted between cells	-	-	✓	✓	opt.
Shading losses	-	-	✓[8]	-	✓
Specific number & size of rows	-	-	Infinite	Infinite	✓
Edge effects modeled	-	-	-	-	✓
1-axis tracking	-	-	✓[9]	✓	✓

$$BG_E[\%] = \varphi_{Pmp} \times \frac{G_{rear}}{G_{front}}(1-\eta_{loss})$$

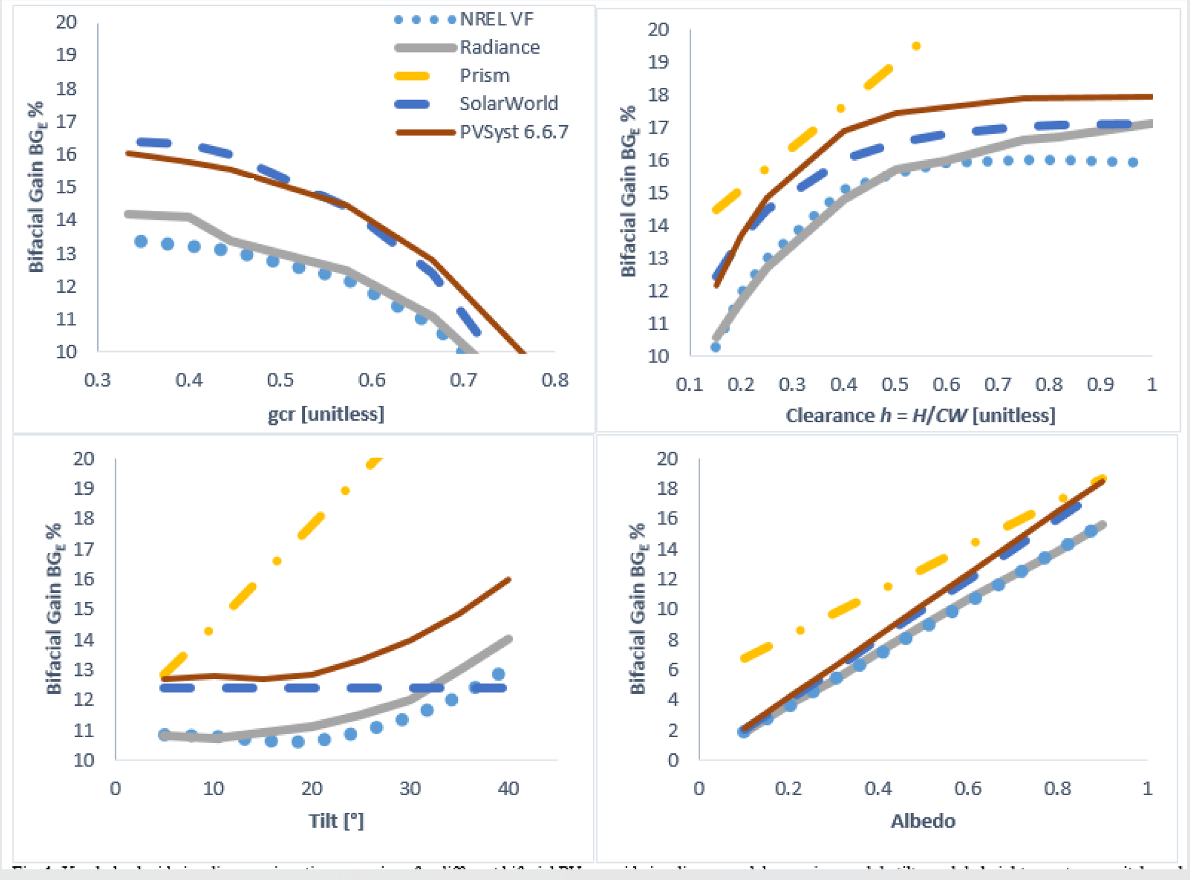
$$\varphi_{Pmp} = \frac{Pmp,rear}{Pmp,front} \times 100\%$$

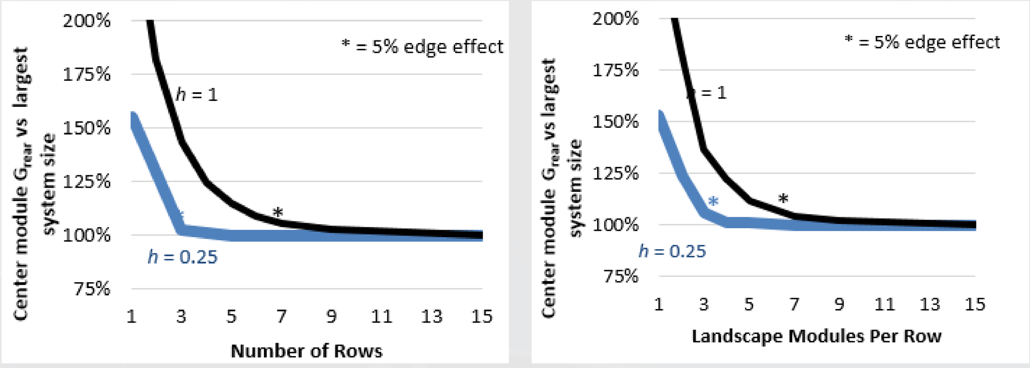
$$nonuniformity = \frac{max\ G_{rear} - min\ G_{rear}}{(max\ G_{rear} + min\ G_{rear})/2}$$

A test-bed was constructed with 6 irradiance sensors (2 top facing, 4 bottom facing) to compare modeled and measured data in Golden, Colorado.

Results

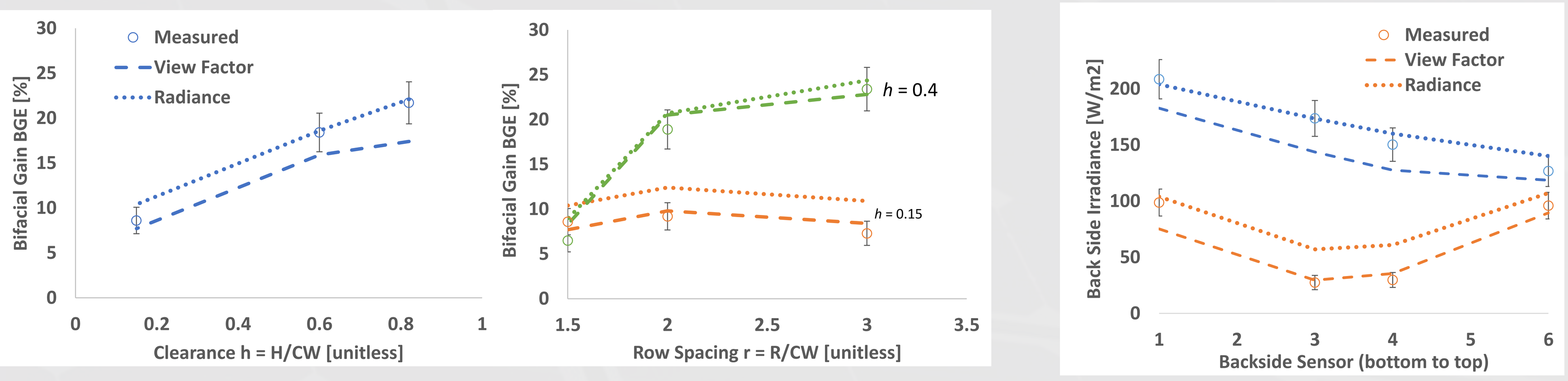
Yearly back side irradiance gain ratio comparison for different bifacial PV rear side irradiance models for Richmond VA location.





The effect of the finite size of the array can be of significance if the system is not large enough to cast representative shade conditions

Model agreement is better than 2-3% when compared with measured results, depending on system configuration.



Varying row-to-row spacing also show <10% difference with the view factor model predictions at lower clearances.

The non-uniformity across the collector width is 23% for h = 0.15, with the average being 82 W/m^2; for h = 0.6 the nonuniformity is 16% at an average of 169 W/m^2.

Conclusions

Bifacial Energy Gains (BG_E) as high as 20% are predicted for some configurations.

Model agreement is generally good for low ground clearance (clearance heights lower than 0.75 times the collector width), but at higher clearances finite system size and edge effects become a significant factor in simulations, stretching assumptions of infinite system extent made in some models.

Also, rear irradiance uniformity is improved at high ground clearance, as expected.

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