Yield Simulations for Horizontal Axis Trackers with Bifacial PV Modules in PVsyst

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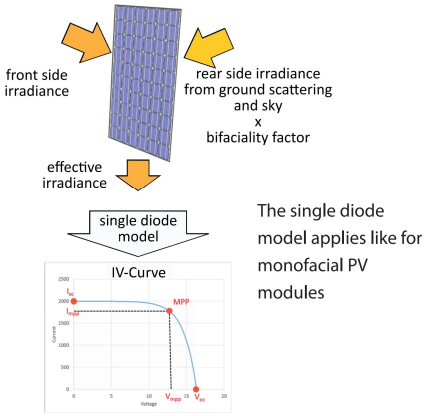
Abstract

The simulation of the energy yield of Bifacial PV modules is not straightforward, since most of the light reaching the back side of the PV modules is scattered back from the ground. For tracking systems this is particularly challenging since the geometry is changing as the sun moves through the sky. In PVsyst, a simplified 2D model was introduced to describe bifacial horizontal single axis trackers with regular spacing. The approach uses view factors to model the fraction of light that is scattered back to the back side of the PV modules. The bifacial calculation includes ground scattering to the front and back side of the modules as well as direct and sky diffuse contributions on the back side.

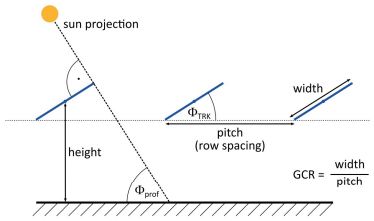
Bifacial model

PV module



The single diode model applies like for monofacial PV modules

2D-model

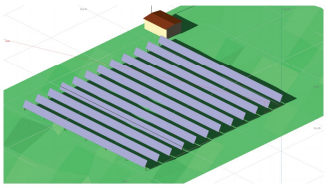


Approximation for modelling ground scattering:
- No contributions from the sides (long rows)
- Ground scattering is the same for all rows (regular width and spacing, many rows)

This allows to use a 2D-cross section of the rows for all the calculations

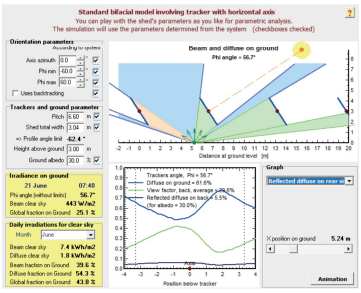
Example of a simulation

Site: Albuquerque NM, 35.05°N, 106.62°W, 1614m ASL
Weather data: Meteonorm 7.1, typical year
Geometry: Pitch=6.6m, width 3m, GCR 45%, height 3m
Ground albedo 30%



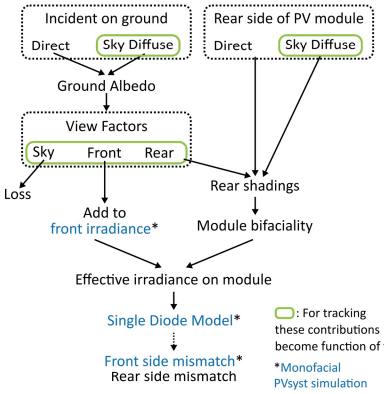
Parameters needed for bifacial simulations:
- Pitch, width, height
- Stroke limits
- Ground albedo (yearly or monthly values)
- Rear side shadings from mounting structures
- Mismatch factor for rear side contribution

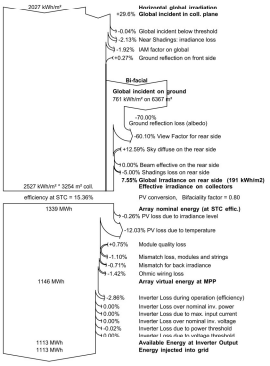
View factors



The view factor describes the fraction of irradiance that reaches a given surface.
View factors are calculated for ground to rear side and ground to front side.

Simulation steps



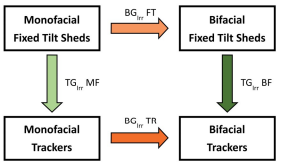


New result variables:
- Irradiance on ground
- Ground reflection loss
- View factor loss
- Diffuse and direct sky irradiance on rear side
- Additional irradiance on rear side
- Ground scattering to front side
- Bifacial mismatch

Parametric studies

Gain factors

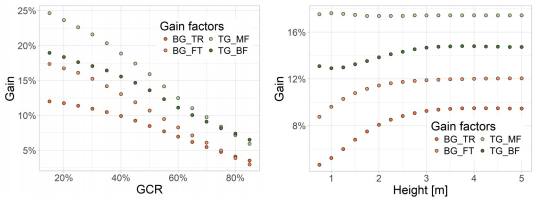
Study the potential benefit coming from Trackers and Bifacial PV Modules



TG : Tracker Gain
BG : Bifacial Gain

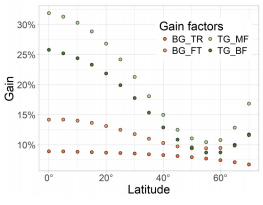
TR : Tracking System
BF : Bifacial System

System configuration (GCR and height)



Bifacial gain and tracking gain are both sensitive to ground covering ratio.
Only bifacial gain depends significantly on mounting height.

Latitude



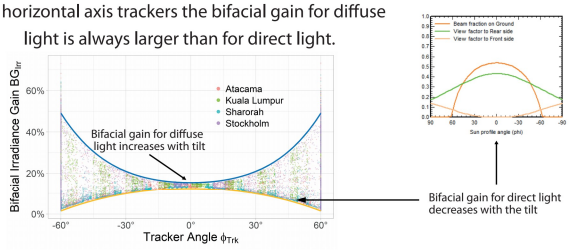
Horizontal axis trackers perform best at low latitudes.
Bifacial systems also benefit slightly from lower latitudes.

Climate

Climates with more diffuse irradiance have a larger bifacial gain.

Site	Sharorah	Atacama	Stockholm	Kuala Lumpur
Latitude	17.5	-23.42	59.35	3.12
Diff/Glob	26.1%	28.6%	49.5%	58.9%
GlobEff	2999	2889	1225	1753
GlobGnd	1059	1008	435	804
GlobBak	286	276	137	236
BG_{bif} TR	**9.5%**	**9.5%**	**11.2%**	**13.5%**

For horizontal axis trackers the bifacial gain for diffuse light is always larger than for direct light.



Direct sunlight
- Irradiance on ground highest for horizontal trackers
- View factor to ground highest for horizontal trackers
- Reflection to front side highest for tilted trackers

The bifacial model used in the PVsyst software, has been extended to horizontal axis tracker systems. The model is based on a simplified view factor approach, that can be reduced to a two-dimensional calculation. This is a suitable approximation for large fields of trackers with regular row spacing and width. The model captures the main bifacial contributions, namely the direct and diffuse light scattered back from the ground, and the direct and diffuse light reaching directly the rear side of the PV modules. The model was used to study the bifacial and tracking gain as function of ground covering ratio, mounting height and latitude, as well as for different climates.