

Webinar PV-Magazine JinkoSolar

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Our bifacial story

- 8+ GW in projects all over the world
- 15 years of industry experience
- More than 1,500 people

2015



'La Silla' solar plant (Chile), 2015. Soltec produced **the first solar tracker specifically designed for bifacial modules** installed in a utility scale solar plant.

2017



Soltec launches SF7 Bifacial Single-Axis Tracker.

- Higher mounting height
- Shadow-free backside
- Wide-aisle reflecting surfaces

2018

Soltec Leads with the World's First Bifacial Tracking Evaluation Center

BiTEC (Bifacial Tracker Evaluation Center) measures bifacial performance and its effect on yield.

2019

2 GW SF7 Bifacial in projects worldwide

Soltec Supplies SF7 Bifacial Single-Axis Tracker for Sao Gonçalo PV plant in Brazil (475 MW)



Bifacial
Tracking,
**The
Real
Deal**



BiTEC

Bifacial Tracker Evaluation Center



Objectives of study from Soltec:

1. Lay out criteria

- Optimal height
- Different Ground color and texture
- Pitch
- Configuration

2. Energy Yield = $f(G, h, \text{Pitch}, \text{Soil color})$

3. Tracking algorithm optimization for bifacial

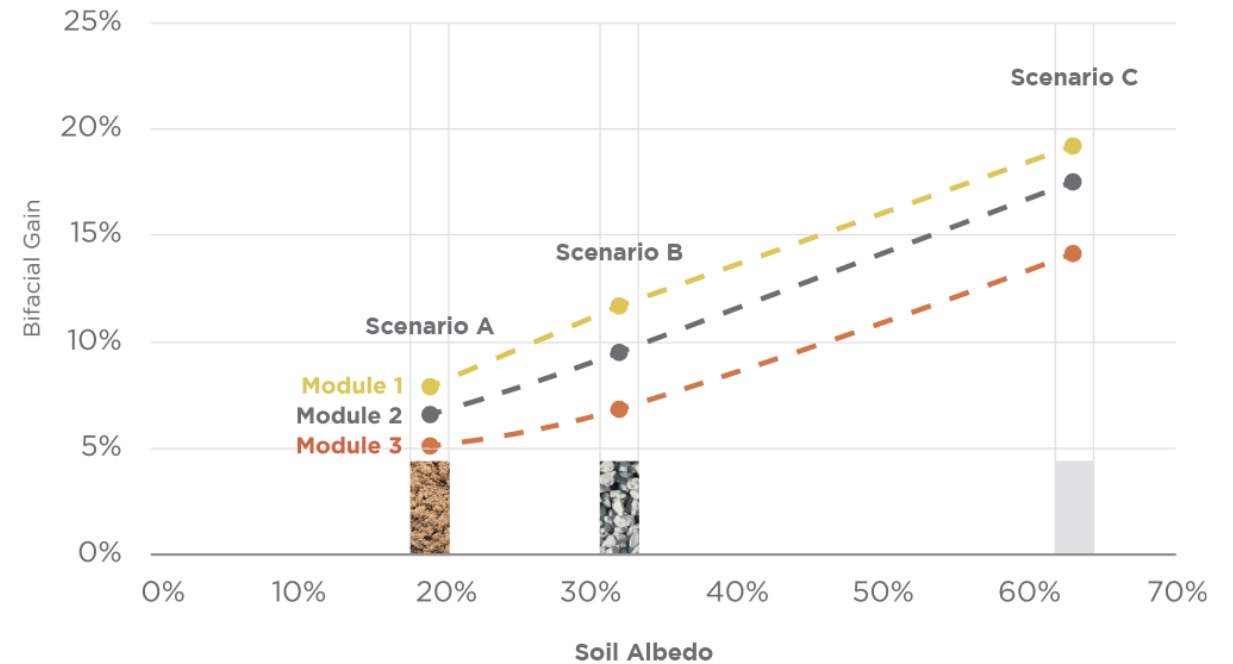
- Measure 3 x different albedos
- Measure 3 x different GCR
- Measure 2 x different heights
- Measure 2 Tracker configurations in real conditions:
 - ✓ Shadow interference losses
 - ✓ Module temperature impact
 - ✓ TeamTrack Backtracking

Bifacial Parameters

Albedo

The albedo varies with the **color and characteristics of the surfaces** that reflect light on to the rear of a module.

Light colored, smooth surfaces have high albedos which can lead to high energy output from the rear of a module.

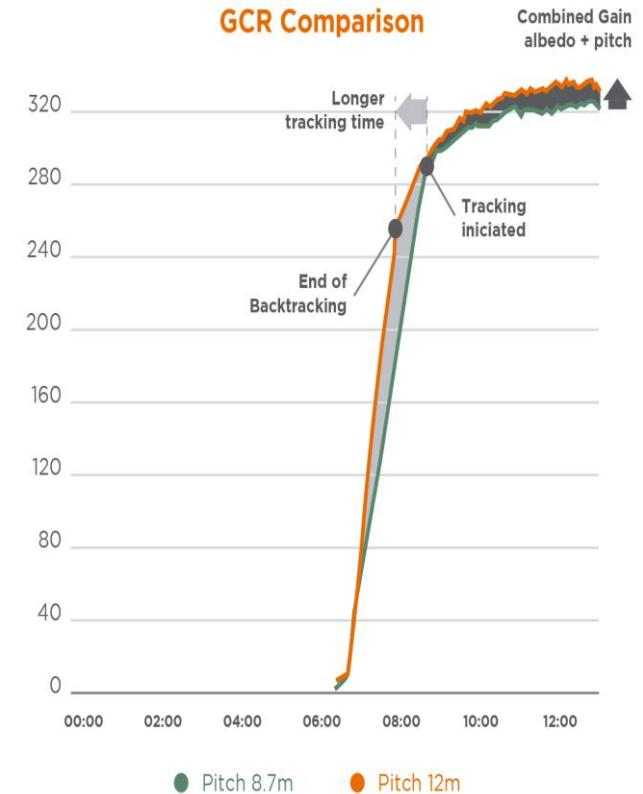
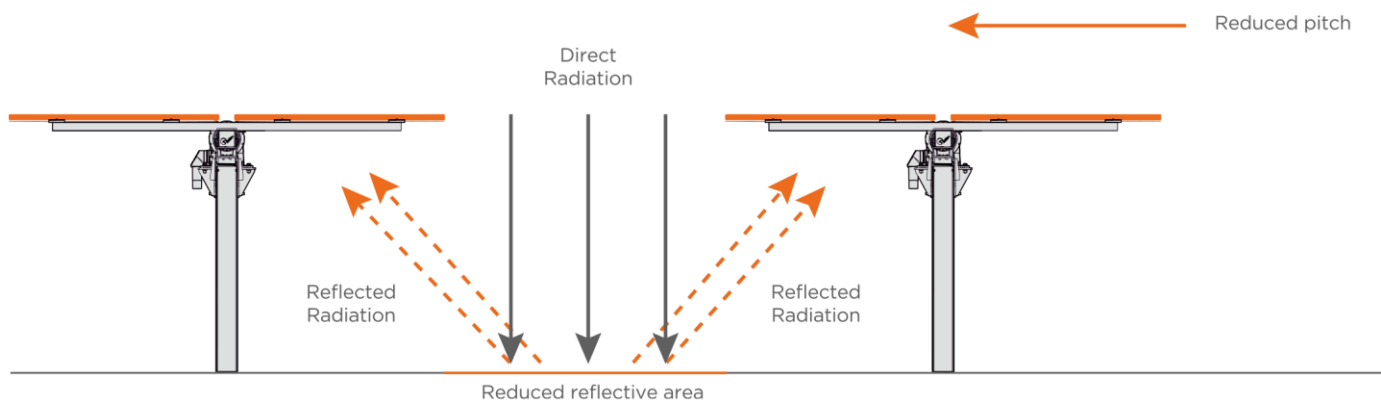
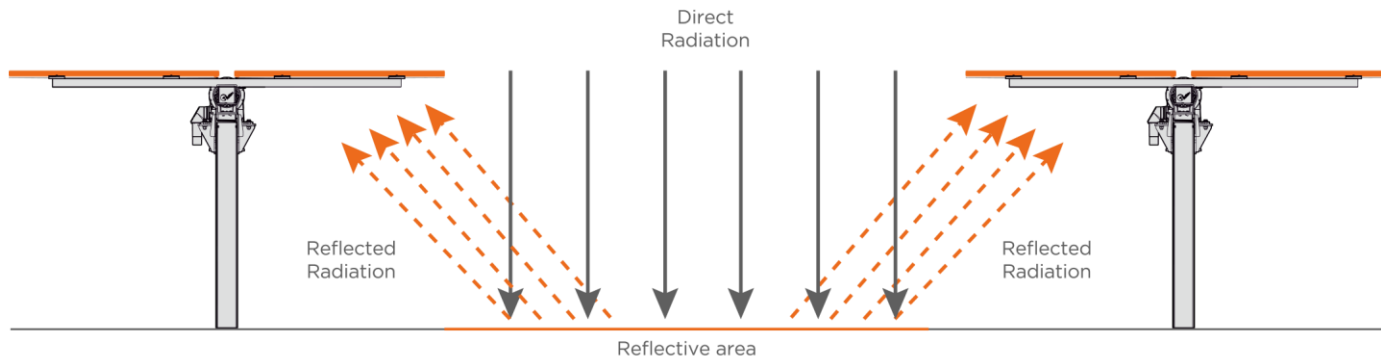


Type of ground	Albedo				Bifacial Gain			
	Fall	Winter	Spring	9 months	Fall	Winter	Spring	9 months
Scenario A: White	62,8%	55,50%	53,2%	58,2%	19,2%	14,3%	13,1%	16,2%
Scenario B: Gravel	32,0%	25,50%	27,2%	29,0%	11,9%	9,3%	7,8%	10,1%
Scenario C: Seasonal	19,2%	17,20%	19,6%	18,9%	7,9%	6,5%	6,1%	7,0%

Bifacial Parameters

Pitch

Pitch	8.7 meters	10 meters	12 meters
Bifacial Gain	9.49%	12.11%	14.58%
Δ	- 2.62%	Baseline	2.47%



Bifacial Parameters

Shading

Racking shading could reach
 ↓ 20% rear irradiation loss

SF7 Bifacial PVSyst simulation
Structure Shading Factor = 0%

Simplified Modeling

PV syst / SAM /
 bifacial radiance

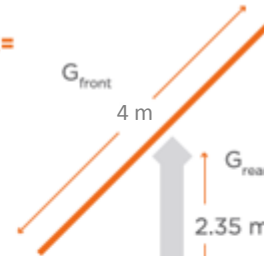
No shading

Module 1 = continuous plane
 No torque tube



Shading factor:
-5.6%

Module 1 + Module 2 =
 continuous plane
 No torque tube



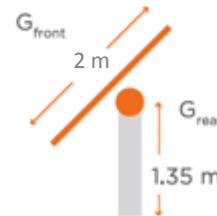
Shading factor:
0%

Comprehensive Modeling

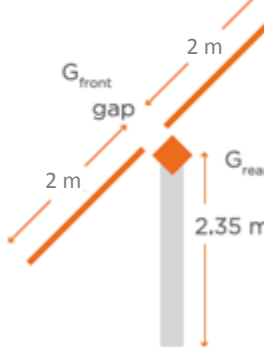
bifacial radiance

Real module location
 torque tube shading

Module 1 = continuous plane
 With torque tube



Module 1 + Gap
 + Module 2
 With torque tube



Example of central row. Simulations count with my rows.

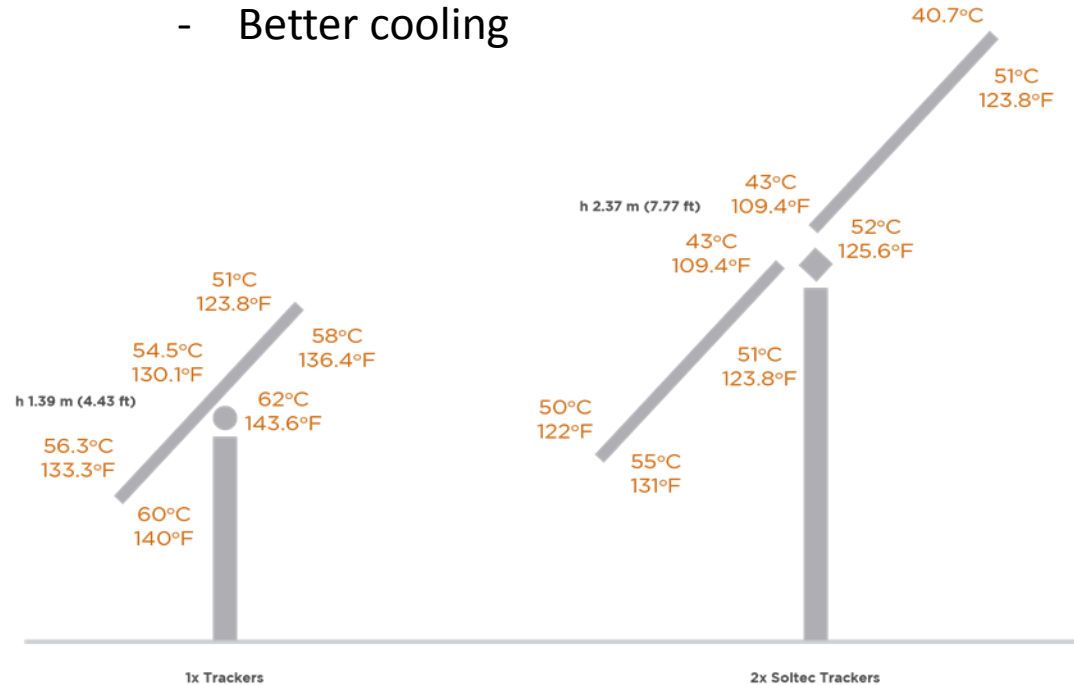


Bifacial Parameters

Module Temperature

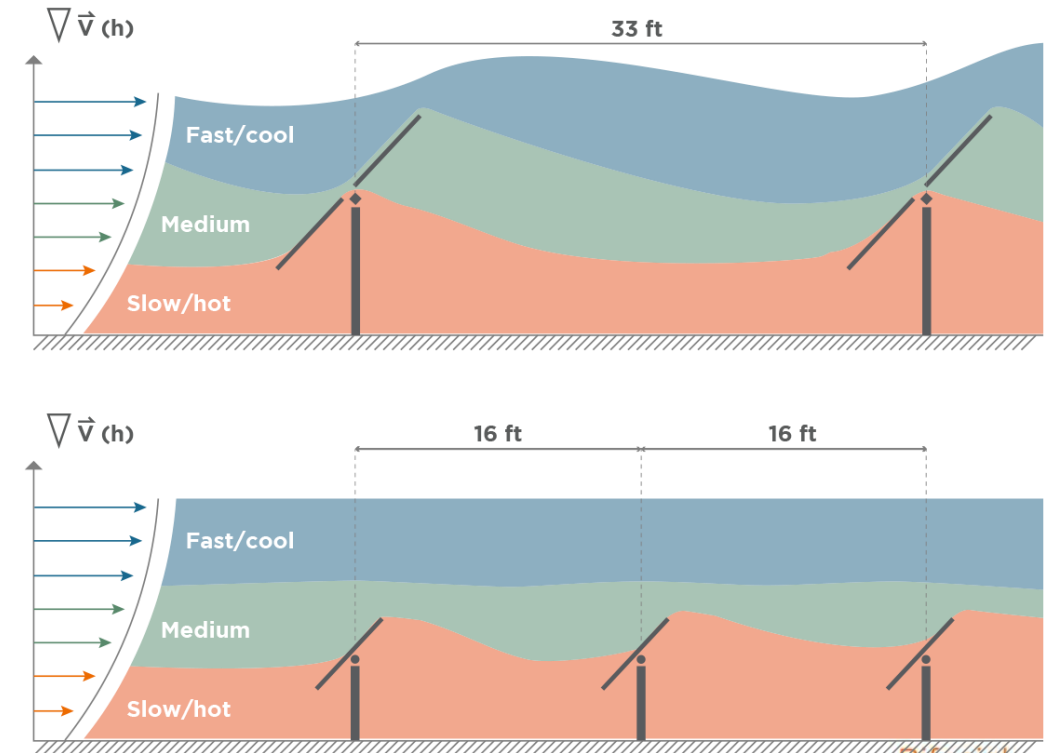
2P SF7 Bifacial +1.2% more power than the module on the 1P tracker because:

- The tracker is higher
- Better cooling



SOLTEC White Papers, link online:
[Bifacial Trackers, The Real deal](#)
[How to simulate Bifacial Projects](#)

2P SF7 Vs. 1P Tracker cooling



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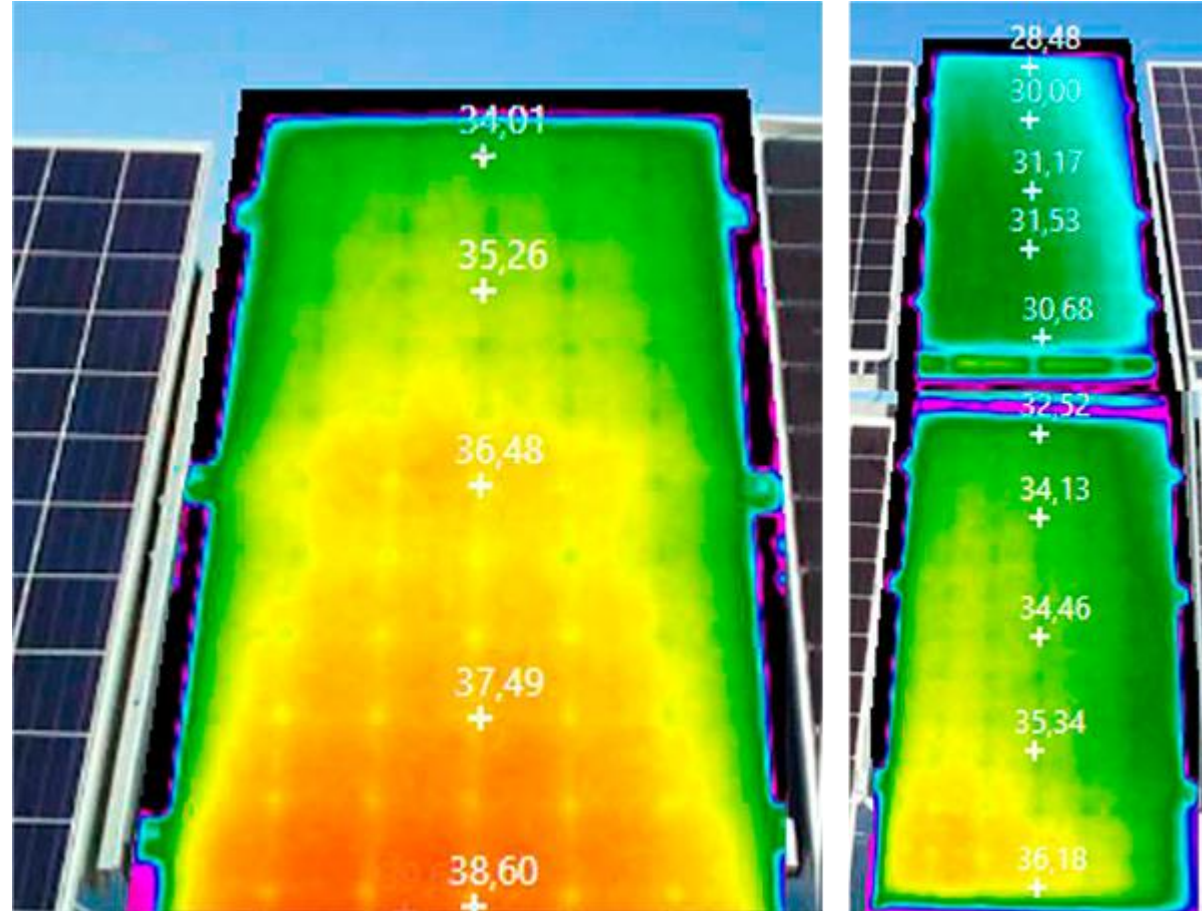


Bifacial Parameters

Module Temperature

Field data from BiTEC shows that **2P module temperatures tend to be lower** than those of **1P trackers**, as seen in this figure.

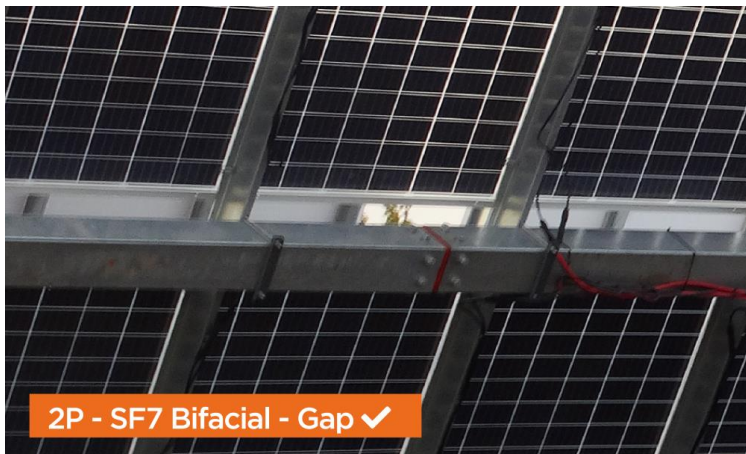
SF7 Bifacial tracker design allows for airflow through the tracker and considers the installation of modules higher above the ground, hence favoring overall cooling. Lower performance temperatures lead to increased power generation.





BITEC: Comparing the Energy Output of Bifacial Modules

1P Solar Trackers Vs. 2P Solar Trackers



Tracker	Height	Albedo	GCR 0.4 Pitch	Bifacial Gain			
				Fall	Winter	Spring	Overall
2P (SF7 Bifacial)	2,35 m	58,2%	10 m	19,2%	14,3%	13,4%	16,3%
1P	1,35 m	58,2%	5 m	16,8%	12,6%	11,4%	14,1%
Δ				2,4%	1,7%	2,0%	2,1%

Parameters	Calculated Bifacial Gain
Lower average module temperature (better cooling)	+1,3%
No torque tube shading	+0,7
Higher module height and other design details	+0,1
Total	2,1%



Parameters adjustments in PVsyst® for the SF7 Bifacial tracker

Parameters	Standard 1P trackers	SF7 Bifacial
Angle	–	-60º +60º
Height	1.35 meters	2.35 meters
Structure Shading Factor	5.6%	0%
Shed Transparent Fraction	MT%	$(MT^* + 3.75) \times 1'017$ (%)
Thermal Loss factor Thermal factor (Uc)	29 W/m2 k	31 W/m2 k
Thermal Loss Factor (Uv)	0 W/m2 k/m/s	1.6 W/m2 k/m/s
Mismatch Loss Factor	10 %	3.1 %

*MT: Module Transparency from module manufacturer

Conclusions

- Bifacial Gain for 2P SF7 Bifacial tracker is **2.1% higher** than a solar tracker with 1P configuration.
- This difference is mainly caused by the **lack of shading in the rear side** of the module, by the **higher position of the solar panels**, and by a **lower operating temperature**.
- Field data from BiTEC obtained between September 2018 and June 2019 show a Bifacial Gain of **16.2%** for individual bifacial tracker modules with an albedo of about 58%.
- Under seasonal albedo conditions, in which ground albedo changes throughout the year, Bifacial Gain was **7%**.
- The specific performance and advantages of bifacial modules can be simulated using available software, such as PVsyst®, provided bifacial parameters are properly entered. To do that, it is necessary to adjust the values for **Structure Shading factor, Shed Transparent fraction, Field Thermal Loss factors and Mismatch Loss factor**.

Case of study

Module Characteristics

Panel Type	Monofacial	Bifacial
Bifacial factor	-	70±5%
Model	Jinko Eagle PERC 72	Jinko SWAN HC 72M
Cell type	Mono PERC	Mono PERC
Cell dim. (mm)	156x156	158,75x158,75
Cell dim. (inch)	6x6	6,25x6,25
Weight (kg)	26.5	23.3
Weight (lbs)	58.4	51.3
Dimesion (mm)	1956x992x40	2031x1008x40
Dimension (inch)	77,01x39,05x1,57	79,96x39,69x1,57
Front-Back surface	None	glass-transparent backsheet
Glass thick. (mm)	4	3.2
Glass thick. (inch)	0.157	0.126
Efficiency (%)	18.57	18.56
Wattage (Wp)	360	380

Eagle PERC 72

340-360 Watt

MONOCRYSTALLINE MODULE

Positive power tolerance of 0~+3%

ISO9001:2008、ISO14001:2004、OHSAS18001
certified factory.

IEC61215、IEC61730 certified products.



PERC

(4BB)



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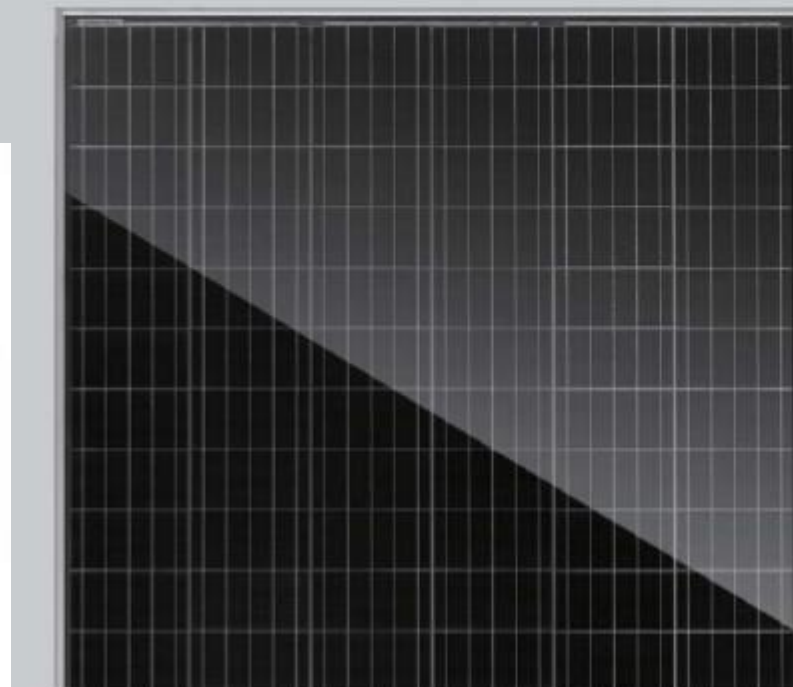
Swan Bifacial HC 72M 380-400 Watt

MONOCRYSTALLINE MODULE

Positive power tolerance of 0~+3%

ISO9001:2008、ISO14001:2004、OHSAS18001
certified factory.

IEC61215、IEC61730 certified products.



Bifacial
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Case of study

- ✓ Location: Livermore – California
- ✓ Latitude: 37.67°
- ✓ PV Plant - Peak Power: 100 MWp
- ✓ Tracker Type: Soltec SF7- 2x28 Portrait
- ✓ Structural Code: ASCE 07/10
- ✓ Stow Strategy: 0°
- ✓ Nr of panels/tracker: 56 (2 strings x 28 panels)

Module Type	JINKO Eagle Monofacial	JINKO Swan Bifacial
Power per module (Wp)	360	380
Power per tracker (Wp)	20160	21280
Tracker Width (m)	3.922	4.212
Tracker Length (m)	28.560	30.324
Tracker Surface (m2)	112.87	127.72
Tracker Power/Surface (W/m2)	178.61	166.61

Wind Type	Panel Array	% of each type Aprox.	Piles per tracker	Simple pile emb. (m)	Total pile emb. (m)	Clearance (m)	Rotation (°)	Rails (mm)
External	2x28	10	5	1.758	3.64	0.5	60	400
Edge	2x28	30	5	1.758	3.64	0.5	60	400
Internal	2x28	60	5	1.758	3.64	0.5	60	400



Soltec

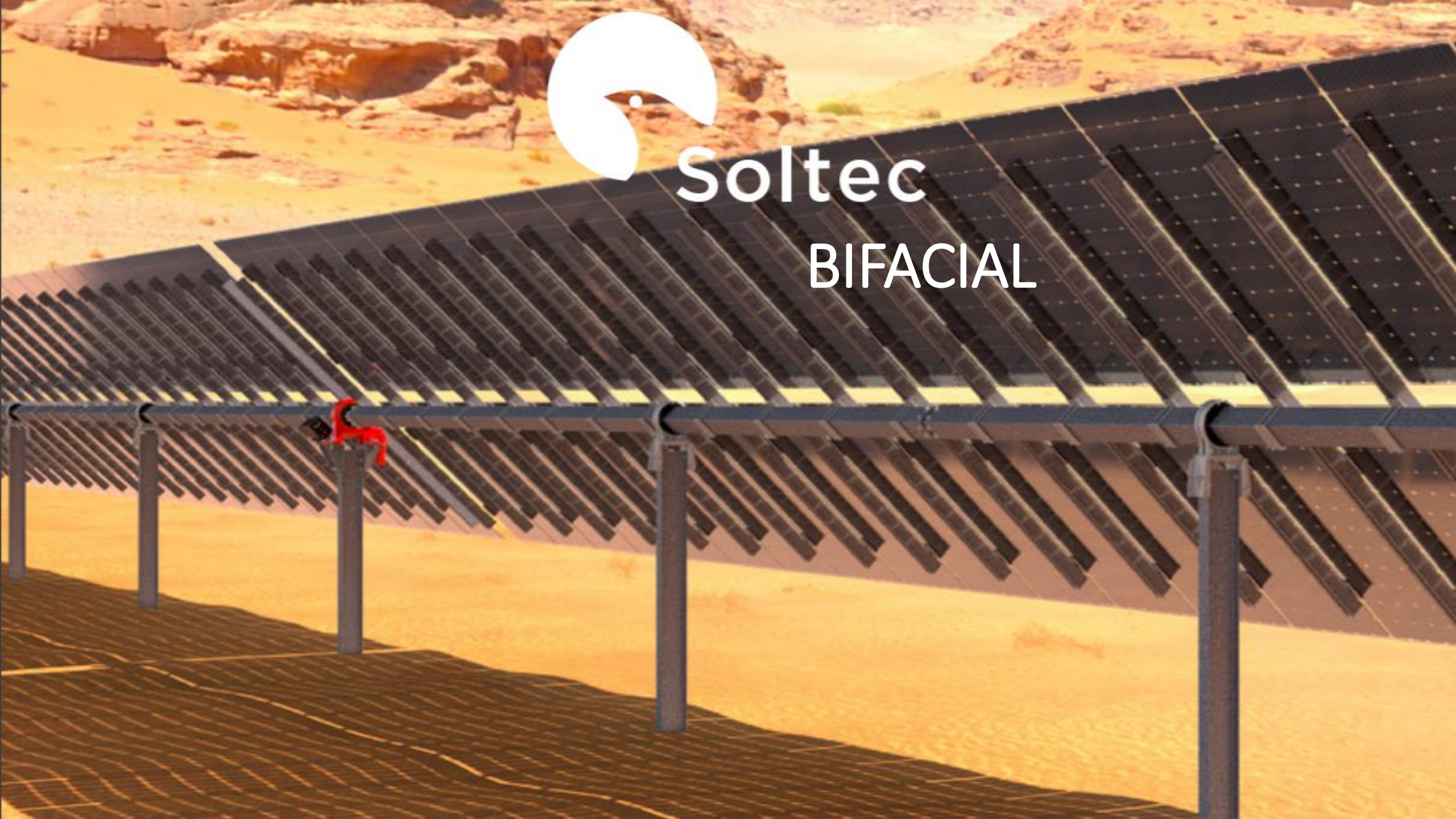
MONOFACIAL





Soltec

BIFACIAL



Results

Tracker and piles total

	Jinko Mono	Jinko SWAN
120 km/h	0,00%	-2,44%
140 km/h	0,28%	-1,86%
160 km/h	1,57%	1,80%

Relative price variation
Reference case: Jinko Mono and 120km/h

	Jinko Mono	Jinko SWAN
120 km/h	0,00%	-2,44%
140 km/h	0,00%	-2,13%
160 km/h	0,00%	0,22%

Relative price variation
Reference case: Jinko Mono

Same amount of trackers

Results

Bifacial gain

	Jinko Mono	Jinko SWAN
120 km/h	0,00%	-7,08%
140 km/h	0,00%	-6,79%
160 km/h	0,00%	-4,55%

Relative price variation for **5% peak power gain**
Reference case: Jinko Mono

Same peak power (less trackers)

	Jinko Mono	Jinko SWAN
120 km/h	0,00%	-15,16%
140 km/h	0,00%	-14,90%
160 km/h	0,00%	-12,85%

Relative price variation for **15% peak power gain**
Reference case: Jinko Mono

Conclusions

- Tracker price is higher at higher wind speeds.
- High efficiency panels (smaller dimensions) are more convenient for high wind regions.
- Relative savings of using bifacial modules are higher in low wind speed regions.
- For the same PV plant peak power the use of bifacial modules decreases the tracker price and overall plant price (lower number of trackers).

BOS analysis

Design Impacts Today

Implementing on US Projects: Single Axis Tracking (1P), albedo in 0.18- 0.2 range (US Regions Without Snow), height 1.4m, Bifaciality Factor 0.7 - 0.75.



Albedo + Bifacial specific Modeling Assumptions
~3.0-5.0% Bifacial Gain



Decrease in Overall System Size DC
~3-5% for the same AC System



Decreased GCR, Depends on Land Constraints in
~ the Range of 0.28 - 0.33



Current Pile Foundation Material and Install \$ =
cost prohibitive to increase Pile Heights to
Increase Bifacial Gain



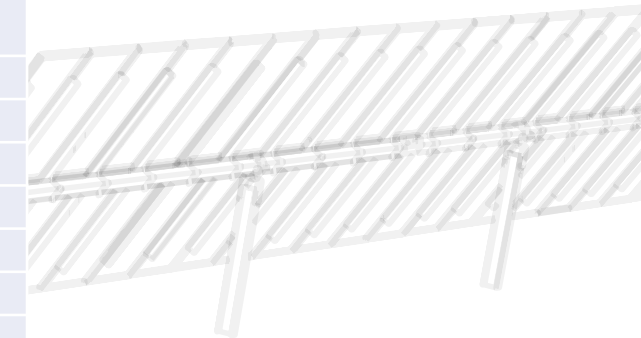
Currently cost prohibitive to change or alter
the utility scale Site Ground Cover

SOURCE: Bifacial Considerations from an Engineering, Procurement & Construction (EPC) Perspective
Beth Copanas, Director Solar Energy September 2019

Payback study

Assumptions

Project Assumptions		Monofacial	Bifacial 5%	Bifacial 15%
Scenario	Tracking	+/-60°	+/-60°	+/-60°
	Pitch	12	12	12
	Installation:	2P	2P	2P
		Jinko Monofacial	Jinko swan Bifacial	Jinko swan Bifacial
Size	MW-AC:	83.3	90.9	90.9
	MW-DC:	100.0	100.0	100.0
CAPEX	PANEL (US\$/Wp):	0.23	0.26	0.26
	BOS (US\$/Wp):	0.30	0.30	0.30
	BOP (US\$/Wp):	0.10	0.10	0.10
		0.63	0.66	0.66
Generation	Bifacial Gain:		5.00%	15.00%
	kWh/kWp:	2,199	2,309	2,529
	kWh/kWp:	142,916	150,062	164,353
Energy price	\$/MWh:	25	25	25
	Esc:	2.0%	2.0%	2.0%
OPEX (all-in)	% of Revenue	10.0%	11.5%	11.5%
Module Degradation	Year 1	3.000%	2.500%	2.500%
	Year 2-5	0.500%	0.384%	0.384%
	Year 6-12	0.714%	0.384%	0.384%
	Year 13+	0.750%	0.384%	0.384%
WACC		6.00%	6.00%	6.00%



Payback study

Payback study

	YEAR 1	YEAR 2	YEAR 3
Generation	219.900	213.303	212.236
Gross Revenue	5.497.500	5.439.227	5.412.030
Net Revenue	4.947.750	4.895.304	4.870.827

	20-yr	25-yr	30-yr
NPV Revenue	53.930.593	59.494.733	63.498.983
CAPEX	63.000.000		
NPV Project	-9.069.407	-3.505.267	498.983

Payback study for trackers with monofacial modules.

	YEAR 1	YEAR 2	YEAR 3
Generation	230.895	225.123	224.258
Gross Revenue	5.772.375	5.740.627	5.718.583
Net Revenue	5.108.552	5.080.455	5.060.946

	20-yr	25-yr	30-yr
NPV Revenue	56.831.294	62.989.058	67.502.826
CAPEX	63.000.000		
NPV Project	-9.168.706	-3.010.942	1.502.826

Payback study for trackers with bifacial modules (bifacial gain 5%).

Payback study

Conclusion

- Payback is shorter when using bifacial modules, consequence of their additional energy output.

	YEAR 1	YEAR 2	YEAR 3
Generation	252.885	246.563	245.616
Gross Revenue	6.322.125	6.287.353	6.263.210
Net Revenue	5.595.081	5.564.308	5.542.941

	20-yr	25-yr	30-yr
NPV Revenue	62.243.798	68.988.016	73.931.667
CAPEX	63.000.000		
NPV Project	-3.756.202	2.988.016	7.931.667

Payback study for trackers with bifacial modules
(bifacial gain 15%).



Thank you

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