Bifacial PV and Tracking - The Simulation and Optimization of Yield Gain

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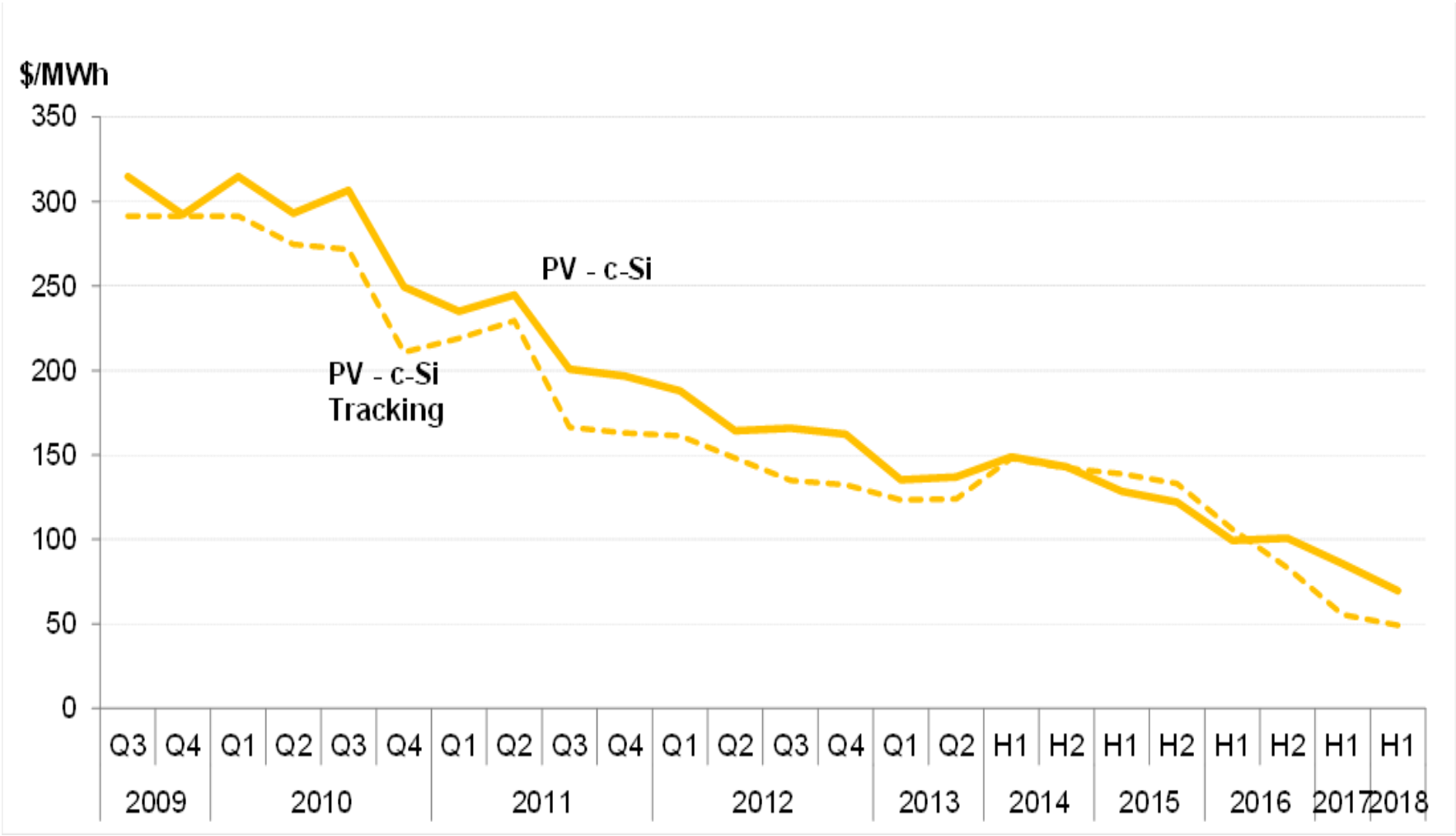
Solar JinKO

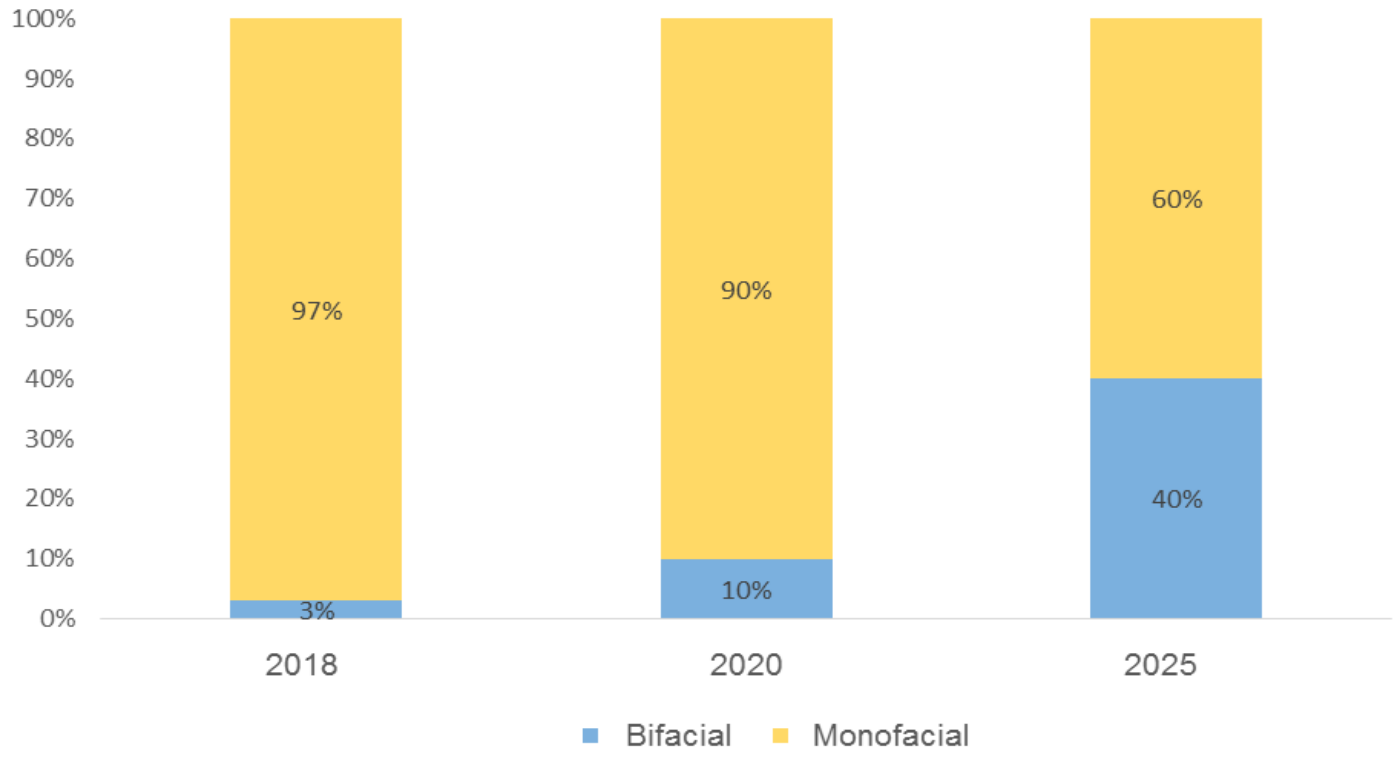
Building Your Trust in Solar

Global PV LCOE Sliding Down



Source: Bloomberg 1H 2018 Solar LCOE Update

Bifacial Modules Market Share Forecast

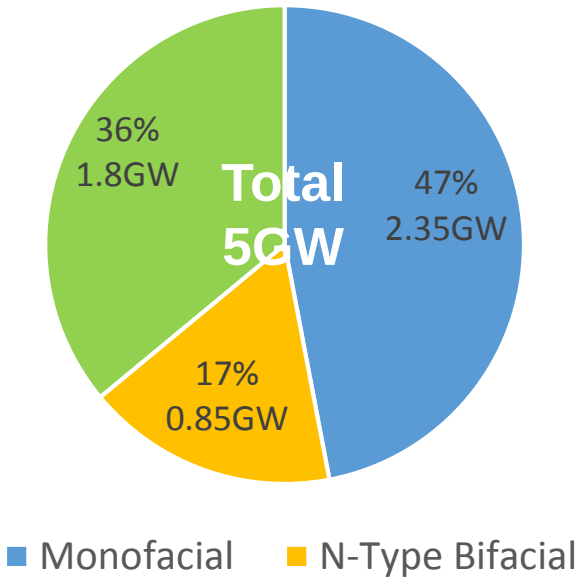


- ✓ 3% Bifacial PV module deployment by 2018
- ✓ China pioneering thanks to its Top Runner program
- ✓ Market share aimed to rise sharply, reaching 40% by 2025

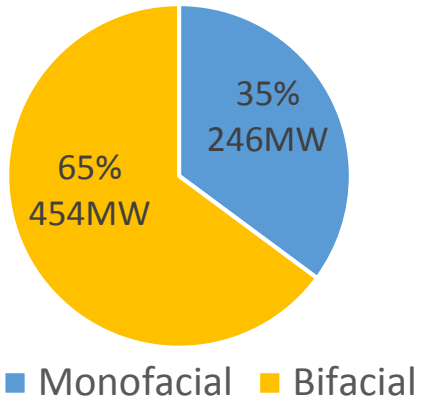
Source: Bloomberg 1H 2018 Solar LCOE Update

Top Runner Programme

Quota allocation for the 3rd Batch of Top Runner in 2017



GCN's module choices in Top Runner Project



- CGN is Jinko's key account in the Top Runner Scheme
- CGN bids for 700MW in total
- 65% with bifacial technology
- 390MW supplied by Jinko of which 200MW Bifacial

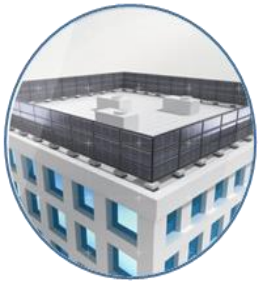
✓Monocrystalline modules, P/N-type, account for 86% (4.3GW)

✓53% Bifacial share (2.65GW)

Source: Bloomberg

Various Application Possibility

Railing

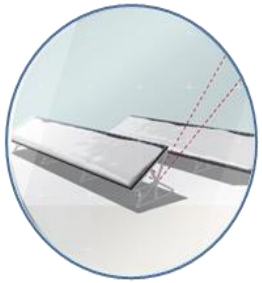


More generation than conventional monofacial module, although it is installed vertically from the sunsun

Soundproof

Various applications utilizing vertical installation advantage

Snow-covered Circumstance



Rear-sided generation in the situation front side is blocked by snow

Carport

Fit for installation situation such as carport that is suitable for take reflection light

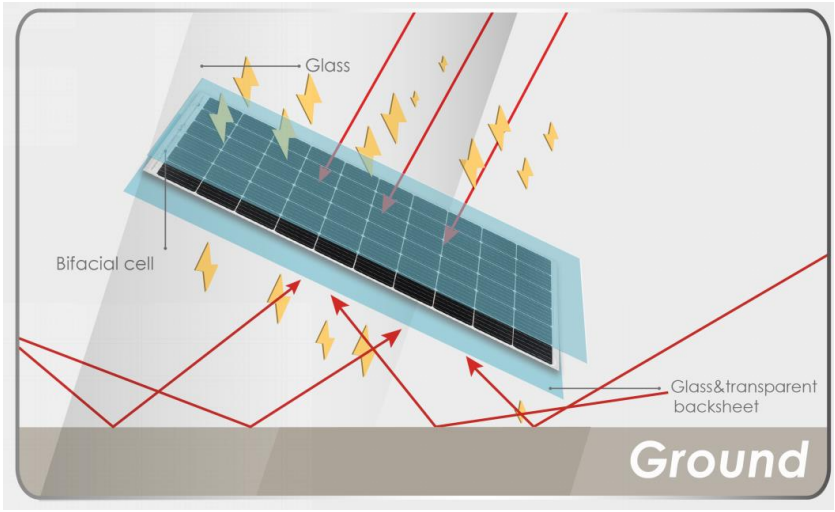
Sun-Tracking Mount

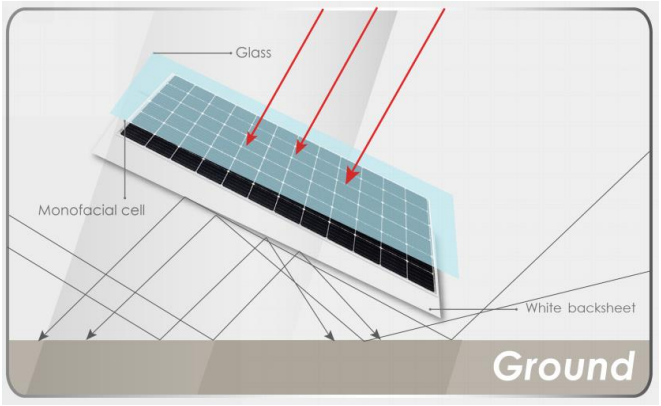
Tracker mount allows for higher output of Bifacial modules

Source: JinkoSolar

Bifacial Modules

When optimized, Bifacial module generates up to **20~30%** more energy
Compared to conventional monofacial module.





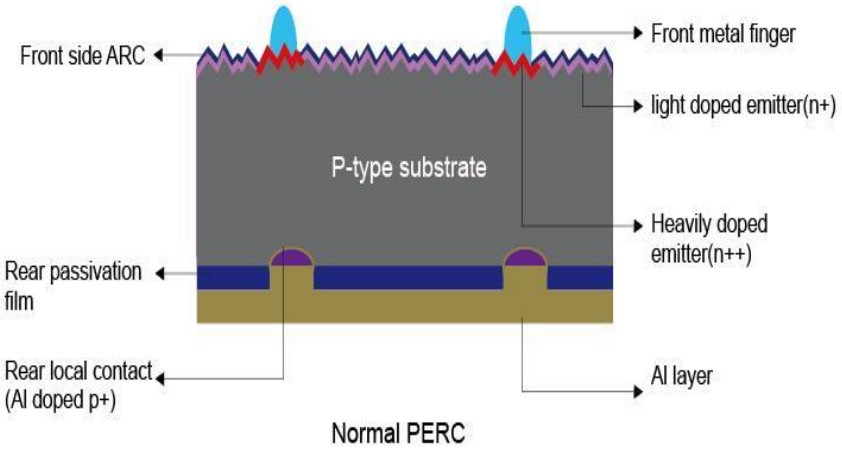
Bifacial module: double-sided generation

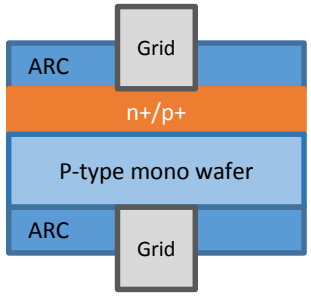
Standard module: front-sided generation only

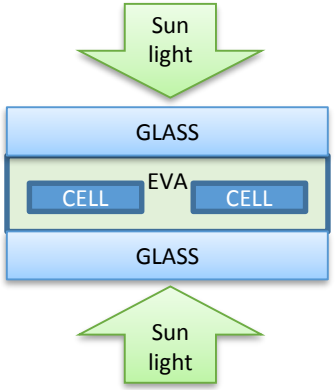
Source: JinkoSolar

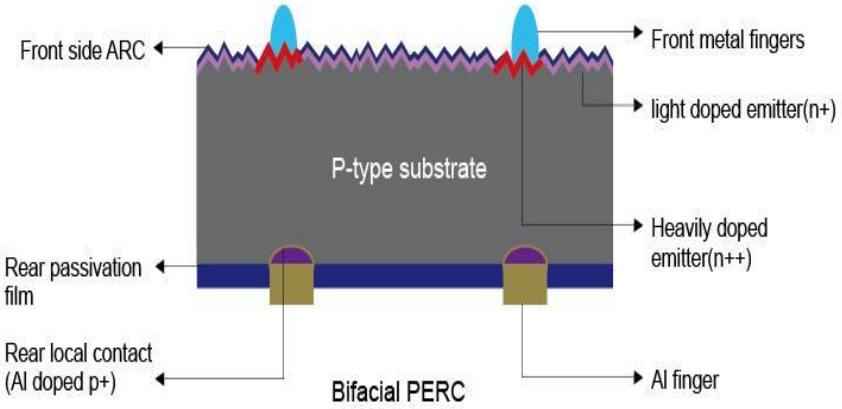
Bifacial: Technical Concept

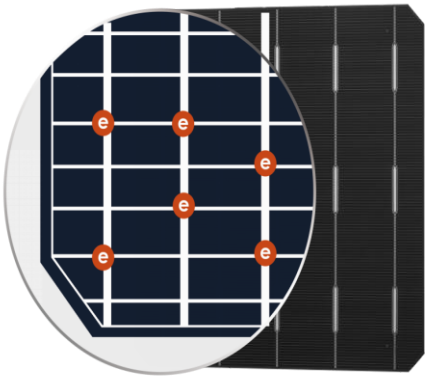
Bifacial Cell & Module Structure



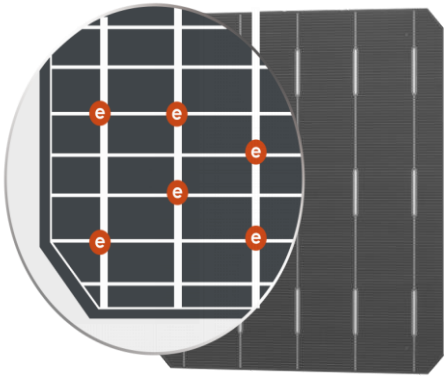








Front Side

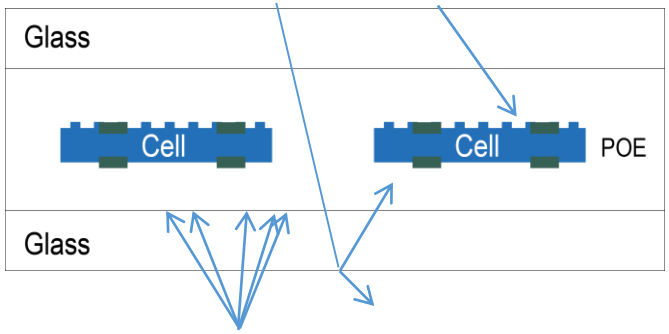


Back Side

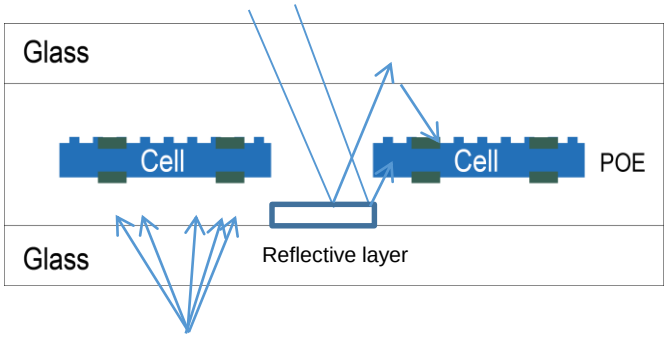
Bifacial Design: Ceramic Glass

+5Wp

Fully transparent rear glass

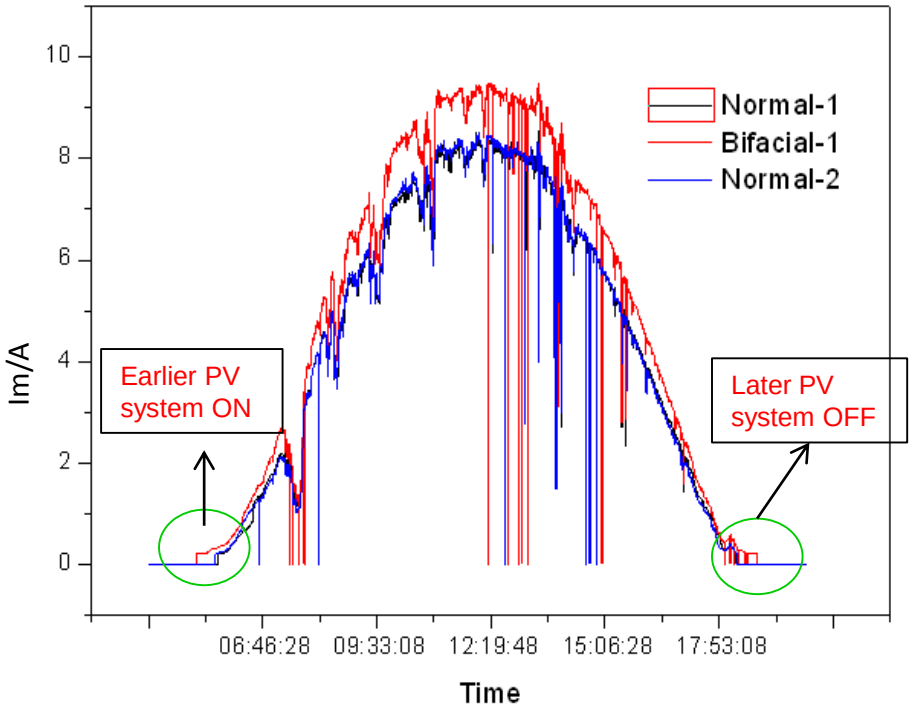


Ceramic glass



Bifacial Characteristic: Low Irradiation Response

Low-Irradiance Response

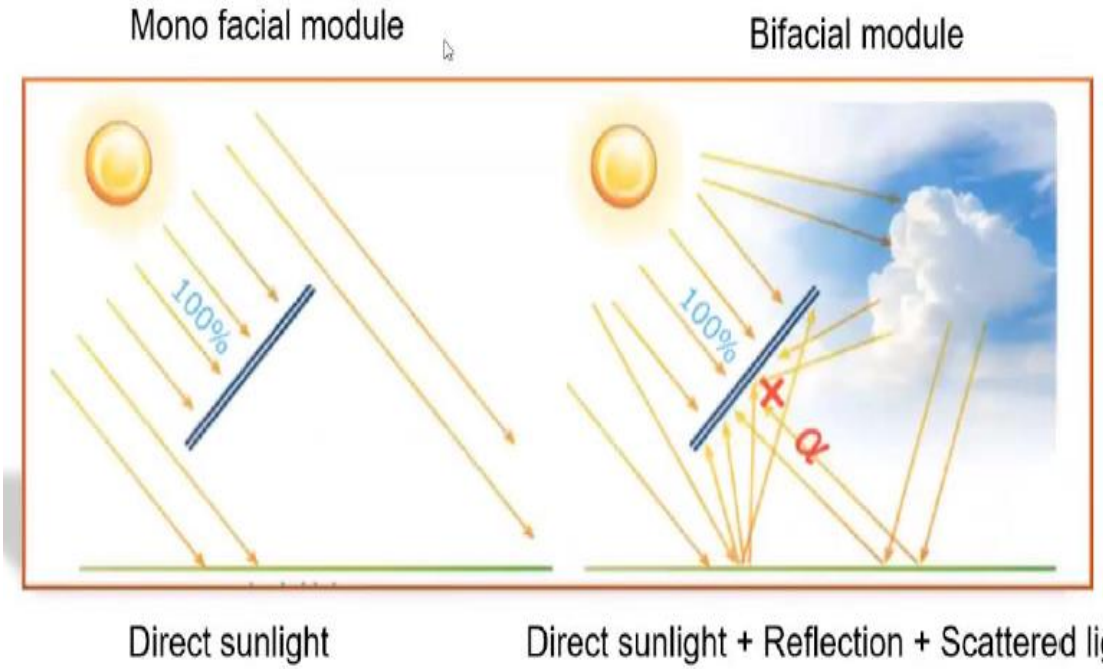


Inverter ON/OFF	Different MPPT	
	start time	end time
Bifacial Module	05:09:48	18:48:48
Normal Module	05:41:38	18:18:08

*Note:
- ✓ Gain compared to monofacial poly
- ✓ The time of Im numerical acquisition is the time when the system starts to generate electricity
- ✓ The steps in the chart represents the time when the module starts/ends generating electricity

Bifacial Module Gain: Albedo

Albedo



Albedo

Fraction of the solar energy reflected from the Earth back into space

$GCR = \frac{Module\ area}{Ground\ area}$ Vs Pitch

Higher GCR implies closer rows

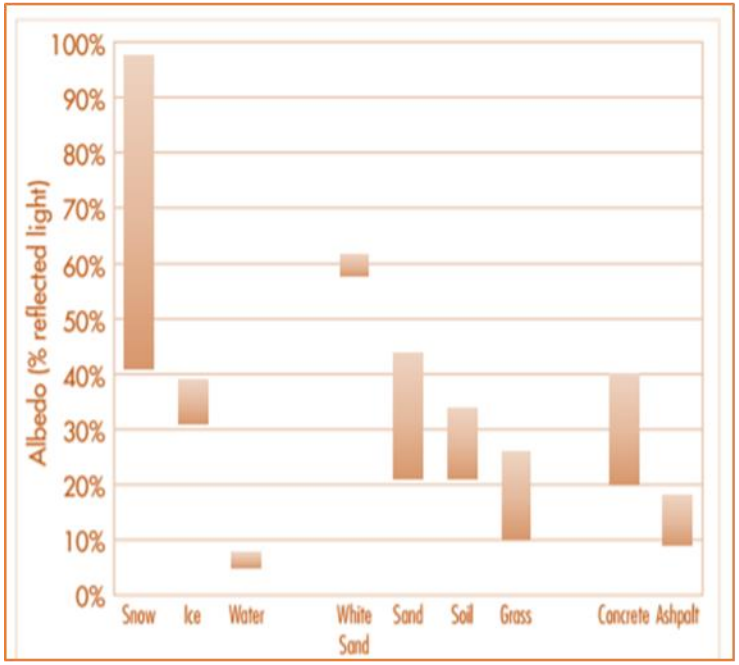
$$albedo = \frac{reflected\ light}{incident\ light} = \frac{Isc\ ground}{Isc\ sky}$$

Source: TÜV Report

Albedo variations – ground type and season

Soil surface: color and texture

↑ white and smooth → ↑ bifacial gain



It can vary with seasons:

Best Case **Snow**

Good Case **White sand**

Medium Case **Ground-grass varieties**

Worst Case **Volcanic Rock**

Source: Soltec

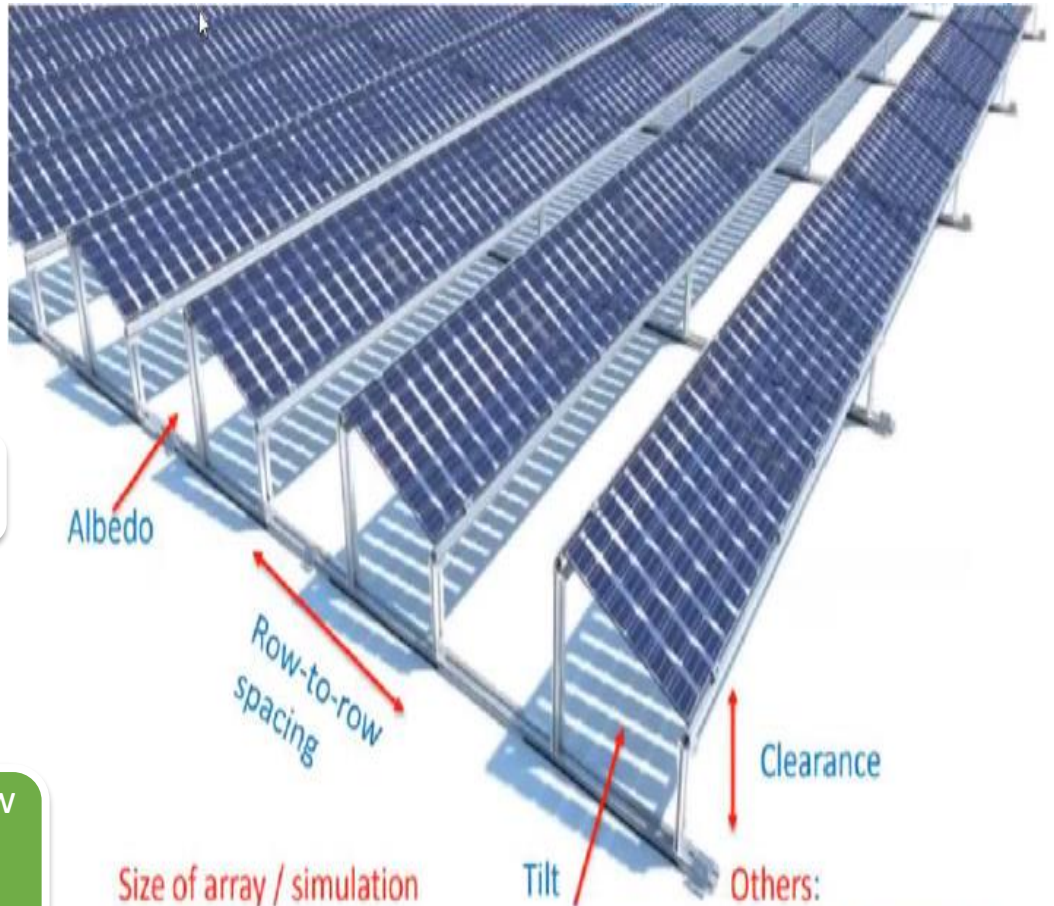
Bifacial Installation Design Parameters

Solar radiation
% Direct / % diffuse

Bifacial Ratio

Soil Albedo
- Color & Texture
- Pitch

Rear Side View
- Height
-Shading

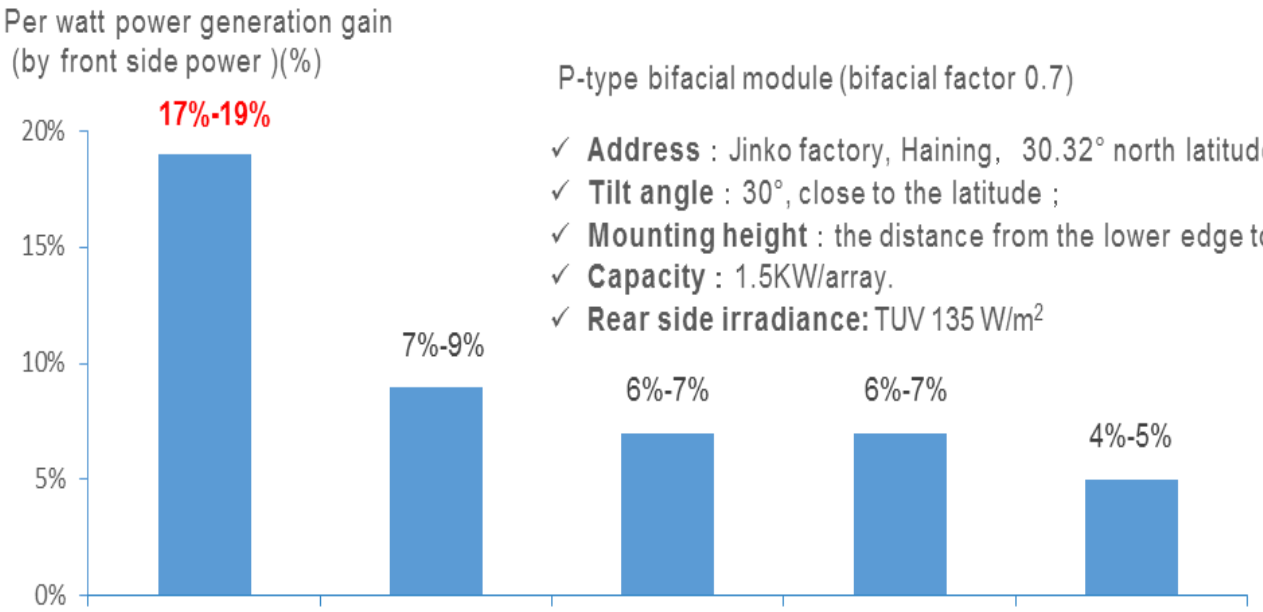


Source: NREL

Bifacial Power Gain– Actual Data

Real Power Generation Gain

Power generation gain of bifacial modules depends on the different ground conditions

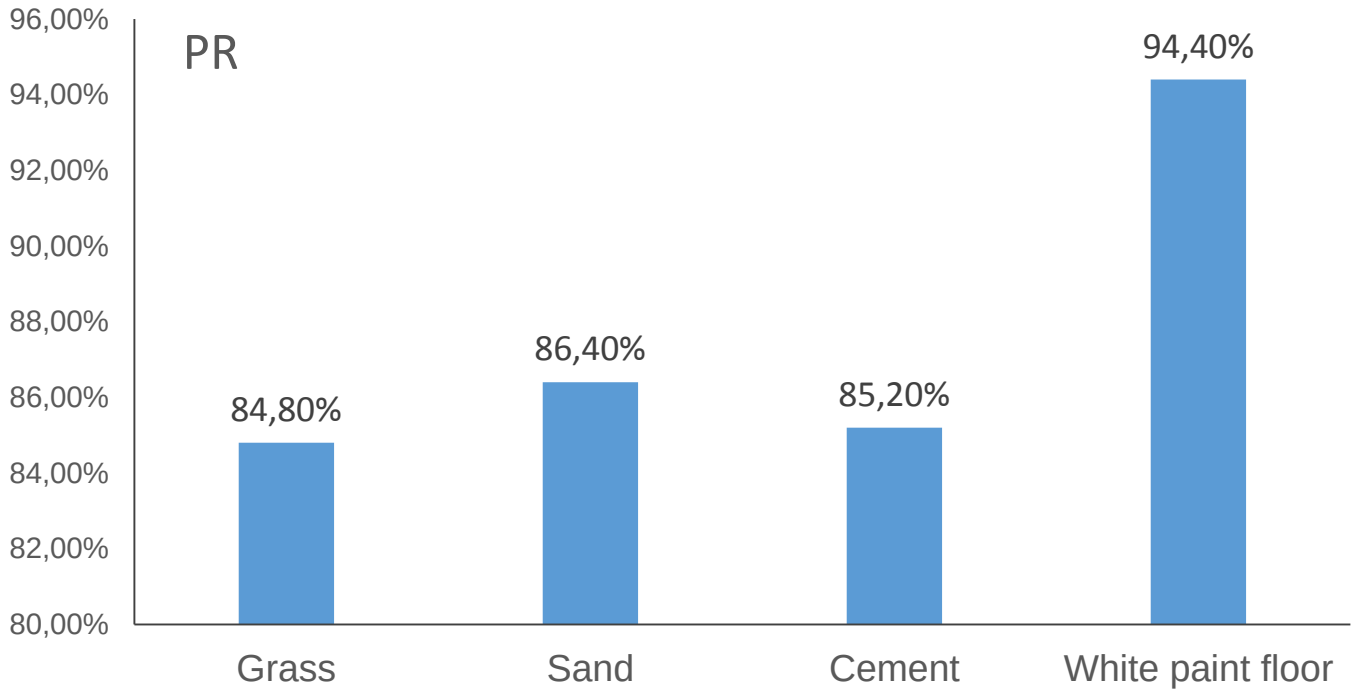


P-type bifacial module (bifacial factor 0.7)

- ✓ **Address** : Jinko factory, Haining, 30.32° north latitude, 120.42° east longitude
- ✓ **Tilt angle** : 30°, close to the latitude ;
- ✓ **Mounting height** : the distance from the lower edge to the ground is 1.0m ;
- ✓ **Capacity** : 1.5KW/array.
- ✓ **Rear side irradiance:** TUV 135 W/m^2

Surface Reflectance

Bifacial Energy Gain: Increased PR Value



P-Type Bifacial 60 cell 310W

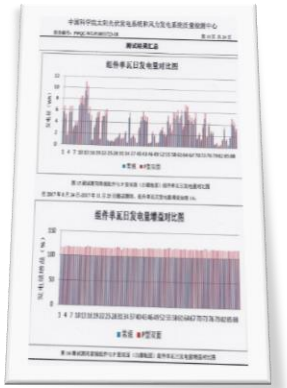
22piece*147string=3234piece（1 MW）

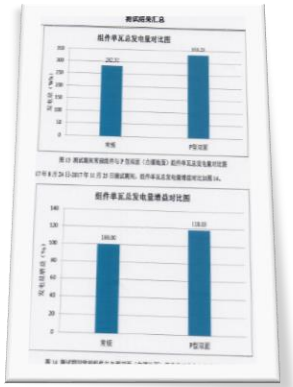
Project in Baicheng, China

Bifacial Energy Gain: Third Party Data

CAS Test Center confirmed that bifacial Module gained **18%** in white-painted ground.


检 测 报 告
TEST REPORT



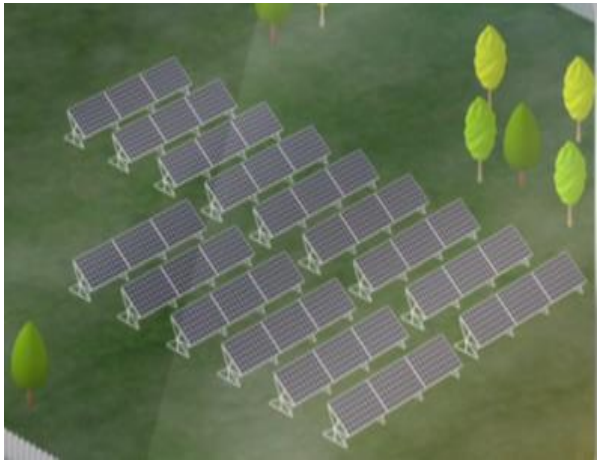


Ground		Water	Grass	Cement	Sand	White-paint
Albedo		~3%	~15%	~32%	~24%	~80%
Actual Data	JINKO	4-5%	6-7%	6-7%	7-9%	17-19%
	Third-Party(CAS)					**18%**
System PR	Baseline=80%	83-84%	84-86%	84-86%	85-90%	93%-96%

Benefits of JinkoSolar Bifacial

Save Module and BOS Cost

Assuming that two solar farms generate same amount of energy (1,414 MWh per year), Jinko solar Bifacial farm can save BOS costs including land area, compared to single-face P-type



260W P type single-face module
2,743ha

Solar JinKO **Bifacial**
2,407ha
(Assuming max rear-sided generation 27.3%)

Benefit of Bifacial: Low LCOE & High IRR

PROJECT	Basic	Pro.1	Pro.2	Pro.3
Project capacity (MWp)	100	Mono Perc	Bifacial	Bifacial
Module Power(W)		380	380	380
Power Warranty(year)		25	30	30
Temperature Coefficiency of Power(%)		0.39	**0.37**	**0.37**
Annual degradation (%)		0.7	0.5	0.5
Bifacial Factor(%)			0.7	0.7
Back Energy Gain			6%	18%
ANALYSIS RESULTS				
LCOE(UScent/kWh)		9.61	8.57	7.70
IRR		13.12%	15.85%	20.97%
PPA price (/KWh)	$0.11			
ENGINEER				
First year front side yield (MWh)		105,315	111,634	124,272
System Voltage(V)		1500	1500	1500
System nominal output at STC(Wdc)		100,005,360	100,005,360	100,005,360
Global inverter power(Wac)		82,500,000	82,500,000	82,500,000

*Notes:
- Frameless module
- Same Capacity: 100MW

*Notes:
- 6% is sand or cement ground
- 18% is white-painted or snow ground

BOS costs savings on:
- Land
- Structures
- Labor
- wiring and cable layout
- O&M activities

- ✓ **Address** : Jinko factory, Haining , 30.32° north latitude, 120.42° east longitude
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