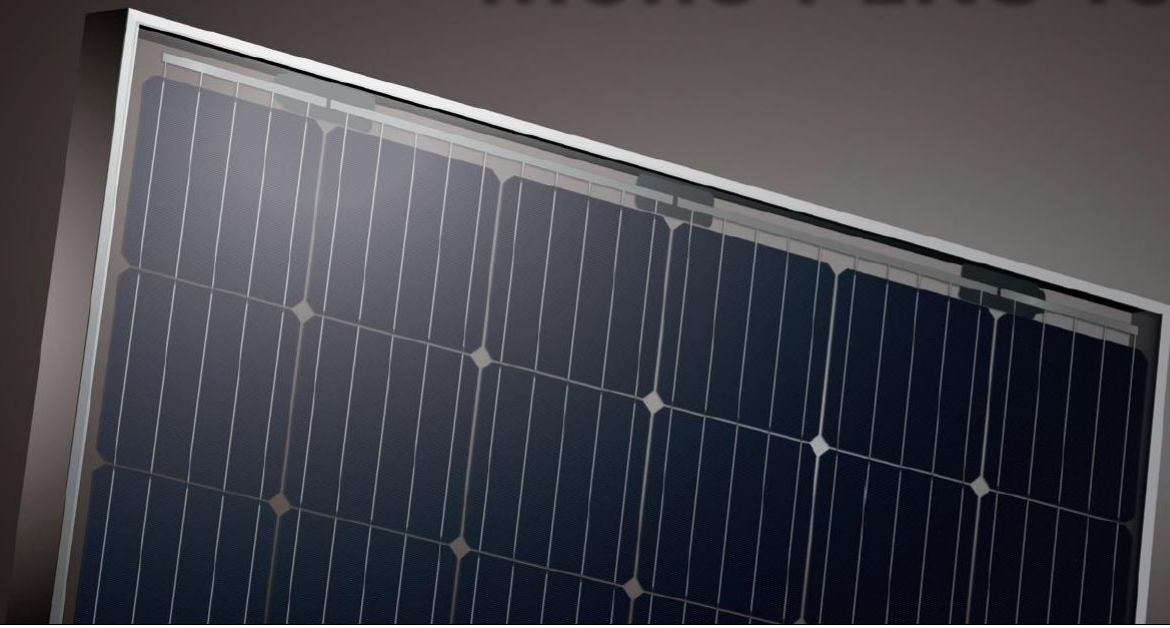


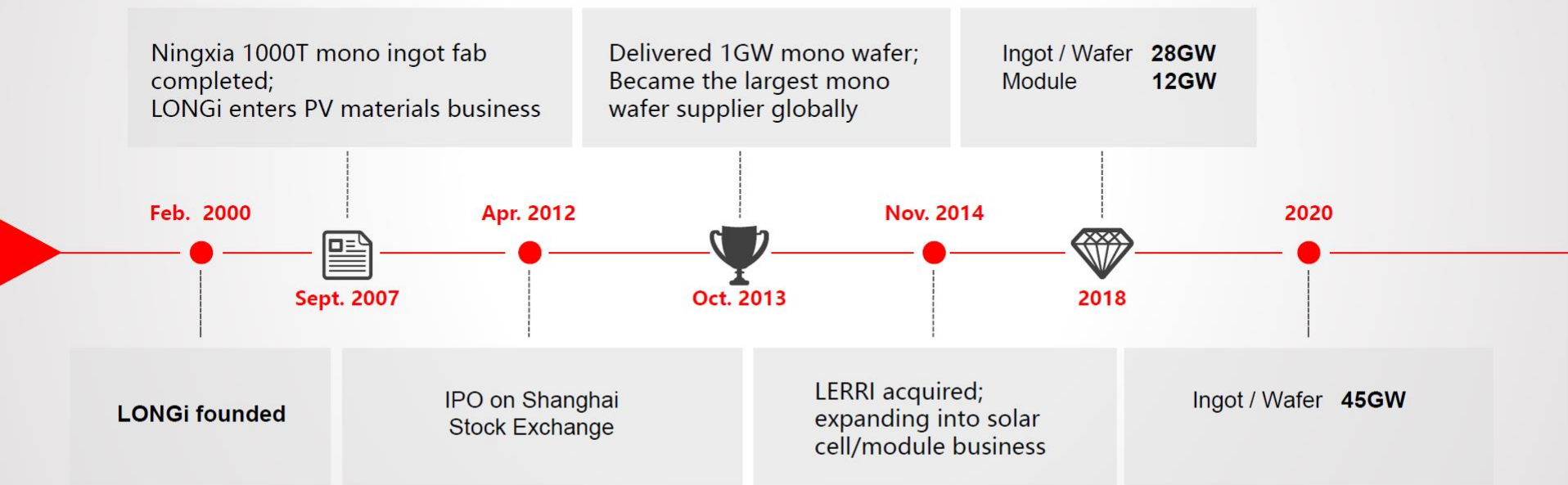
LONGi Solar

LONGi Solar and Mono PERC Technology

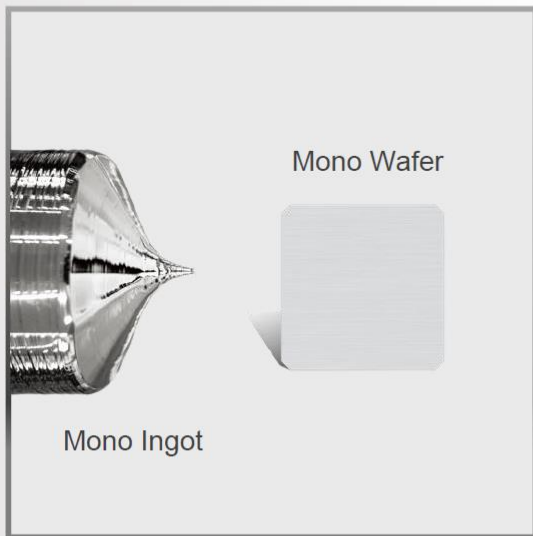


LONGi Solar Milestone

Dedicated in Mono **19 years**



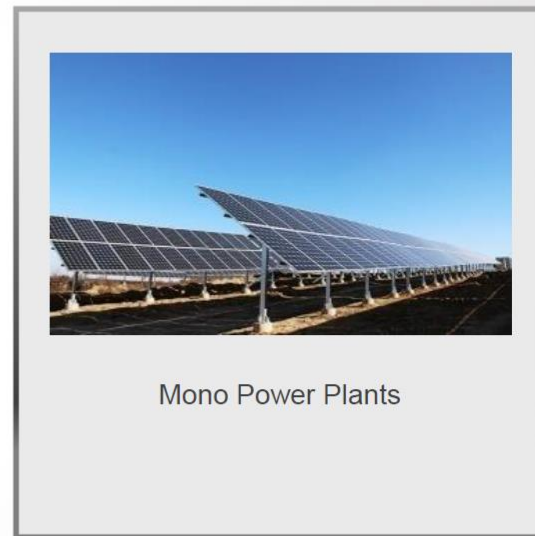
LONGi Green Energy Technology Company



LONGi Silicon



LONGi Solar



LONGi Energy

Technology Strength

\$379 M

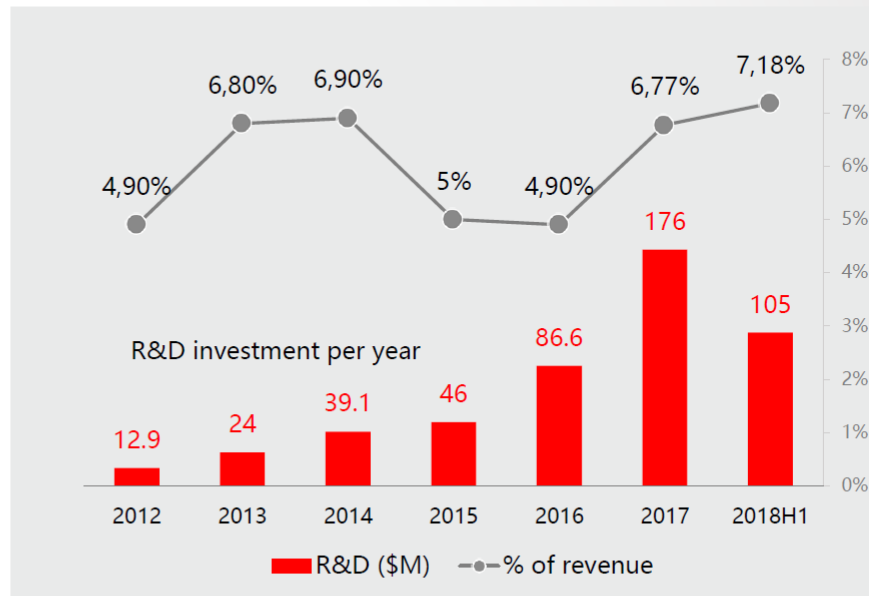
2012-2017 accumulated

R&D spending

5-7% (of revenue)

407 patents awarded

460 staff member



Strategic Partners

Research Institute



Materials



Product Offering

Hi-MO 1

PERC



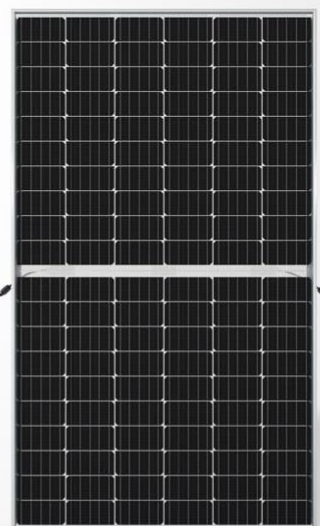
Hi-MO 2

Bifacial PERC



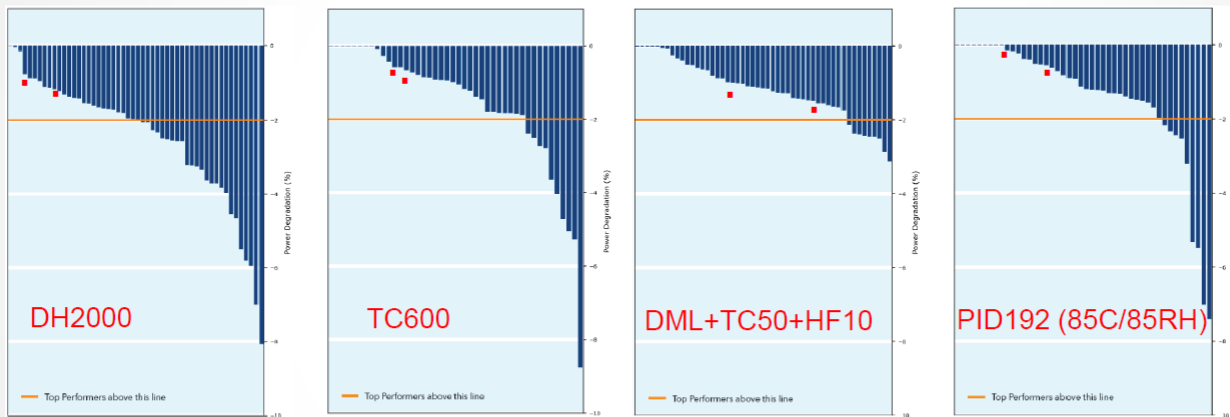
Hi-MO 3

Half-cut Bifacial PERC



High Reliability

DNV-GL Reliability Scorecard

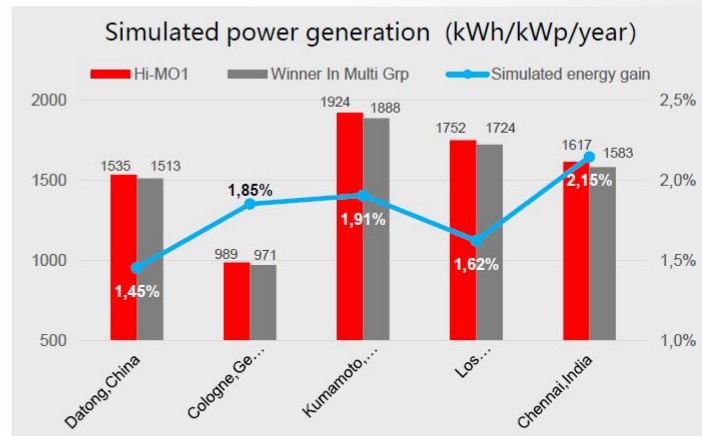


LONGi Solar modules are among **Top Performers** for **All** extended reliability tests

Better Energy Yield with PERC Modules

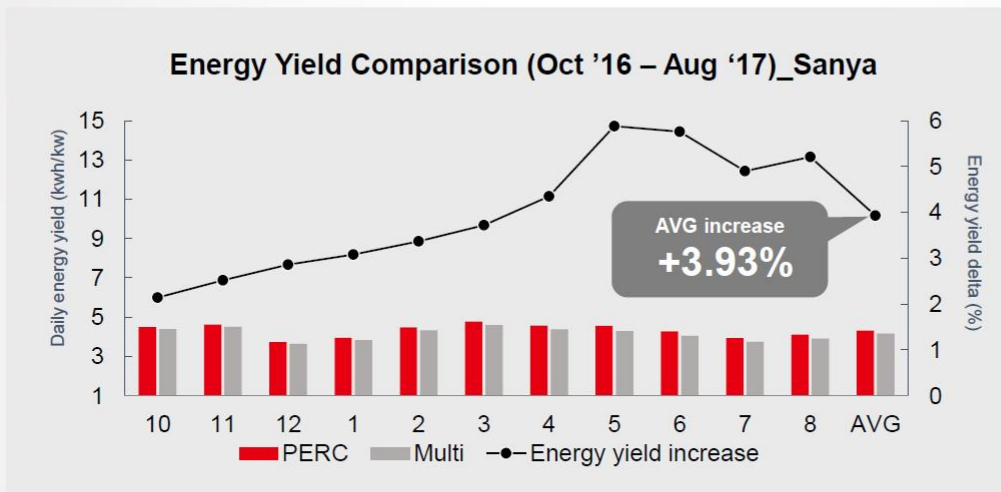


LONGi mono PERC module has been ranked **No. 1** in TUV Rheinland energy yield simulation for two consecutive years



- TUV Rheinland established module PAN file with performance measurement under different irradiance, temperature and incident angle using randomly selected module samples from production shipment
- Simulated energy yield in five different cities globally

Better Energy Yield with PERC Modules



Contributions:

- Better performance at low irradiance
- Lower operation temp
- Better TempCo with PERC



South China,
(N18.2° / E109.5°)
hot and humid

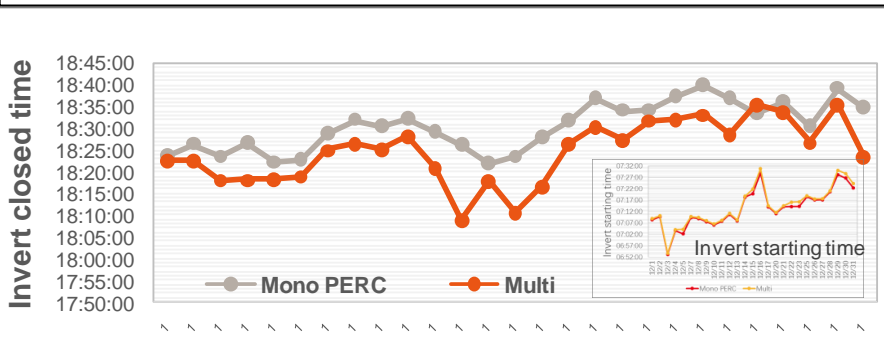
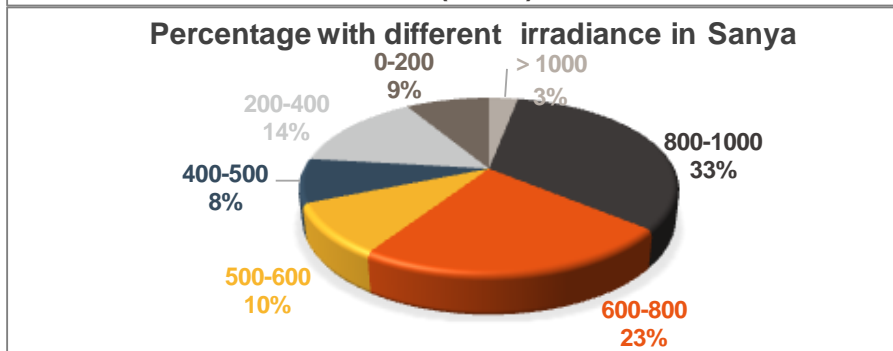
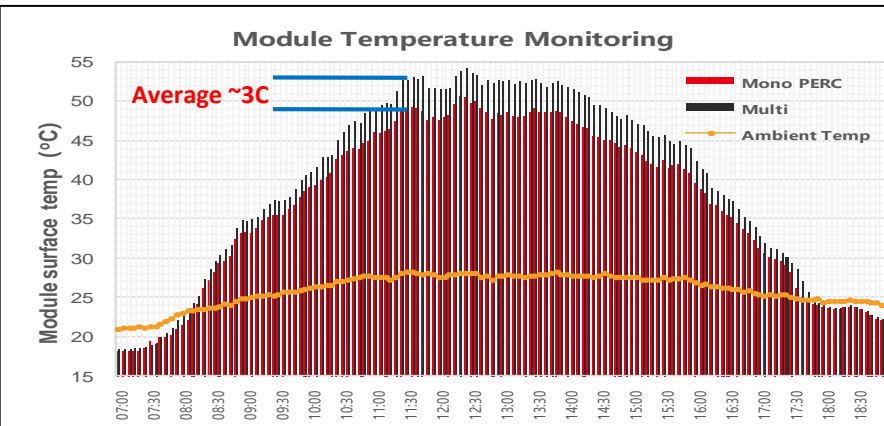
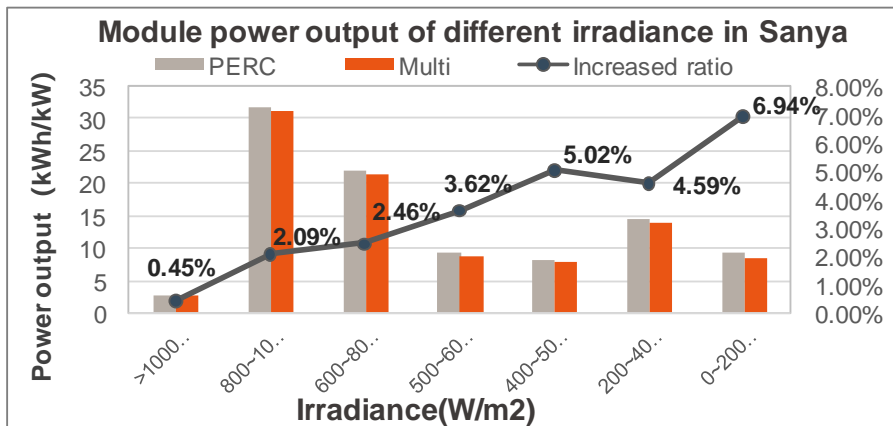
System setup:
8pcs 290W Hi-MO1 module and
260W Multi modules (Tier1
supplier), 3kw inverter

Data source:
China Electric Institute

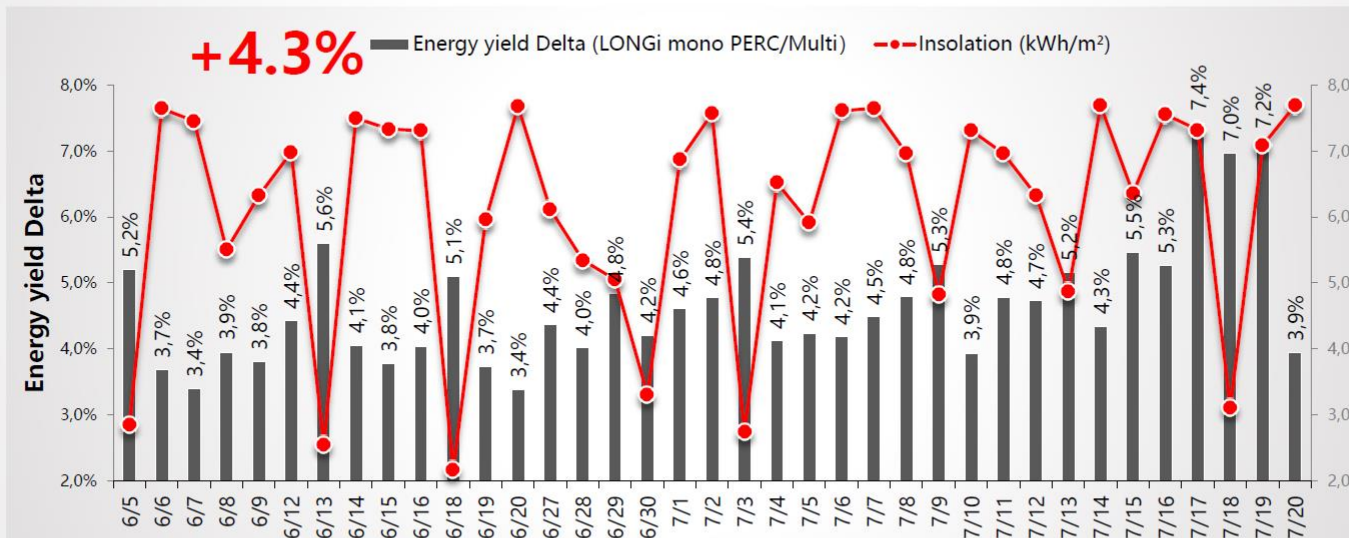


PERC module power generation is > 3% higher than Multi module

Better Energy Yield: Contributing Factors

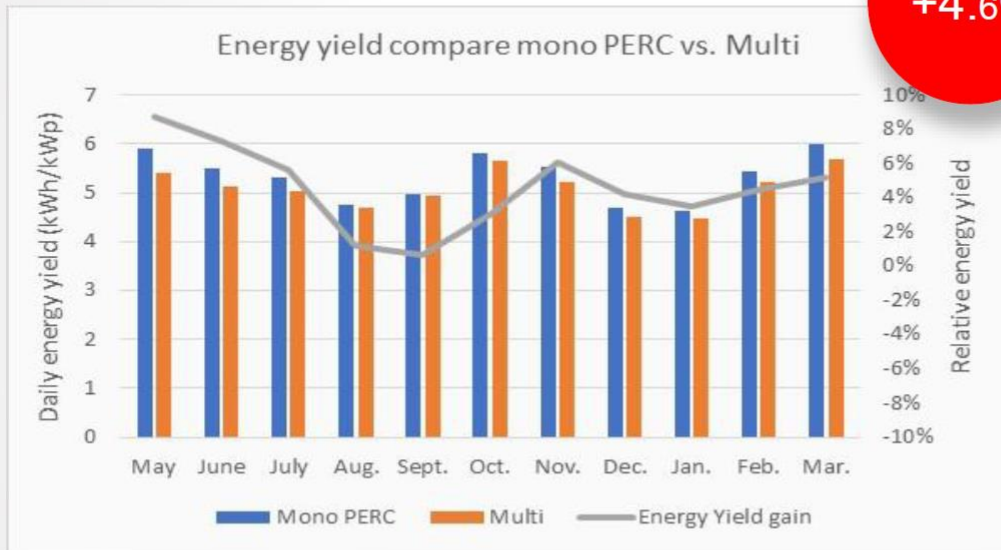


Better Energy Yield with PERC Modules



- Testing period: 6/5/2018 – 7/20/2018
- Under low irradiance condition, mono PERC shows better energy yield: spectra shift to long wavelength at low irradiance, and PERC shows better long wavelength response

Better Energy Yield with PERC Modules



+4.6%



Three Gorge project: 125kW
Location: N36.35, E95.26
Fixed tilt

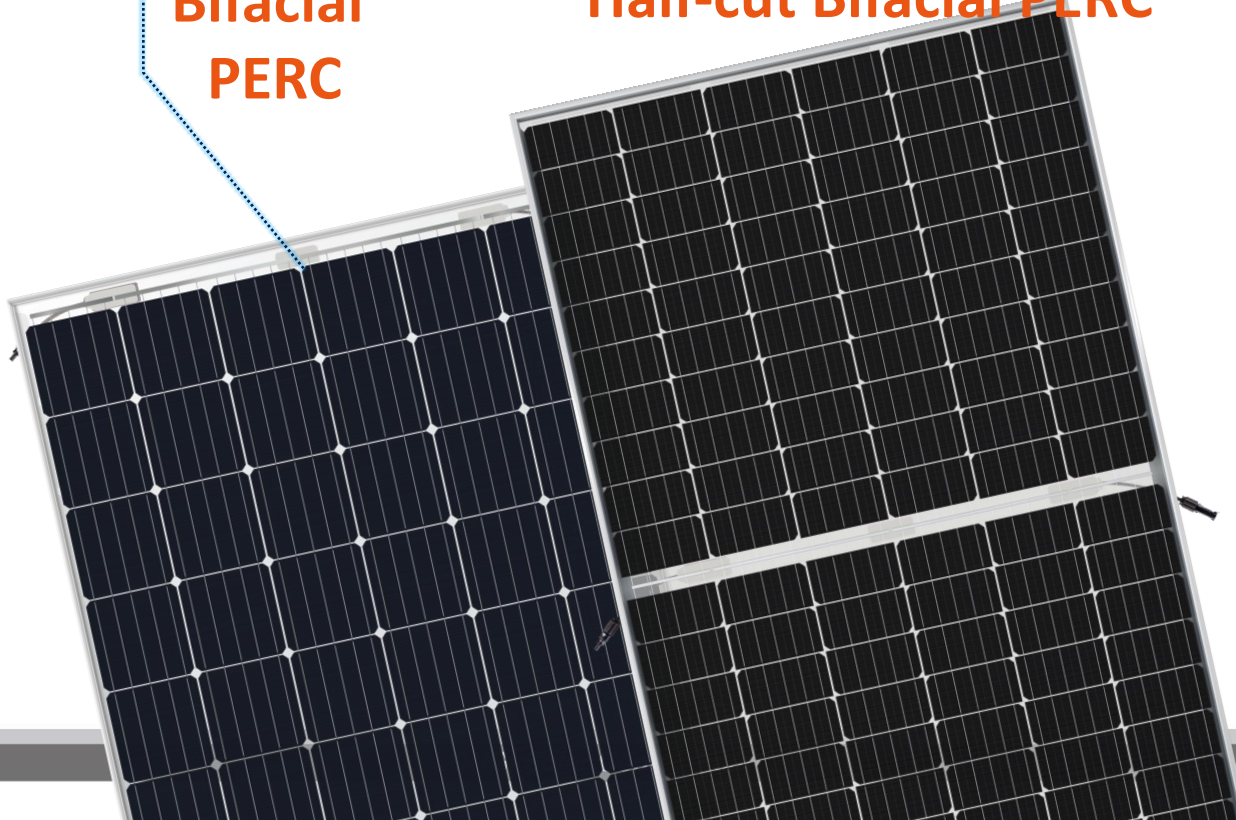
PERC module power generation is >4% higher than Multi module

Hi-MO 2

**Bifacial
PERC**

Hi-MO 3

Half-cut Bifacial PERC



Bifacial Module Design with Frame

Mounting & Grounding Holes

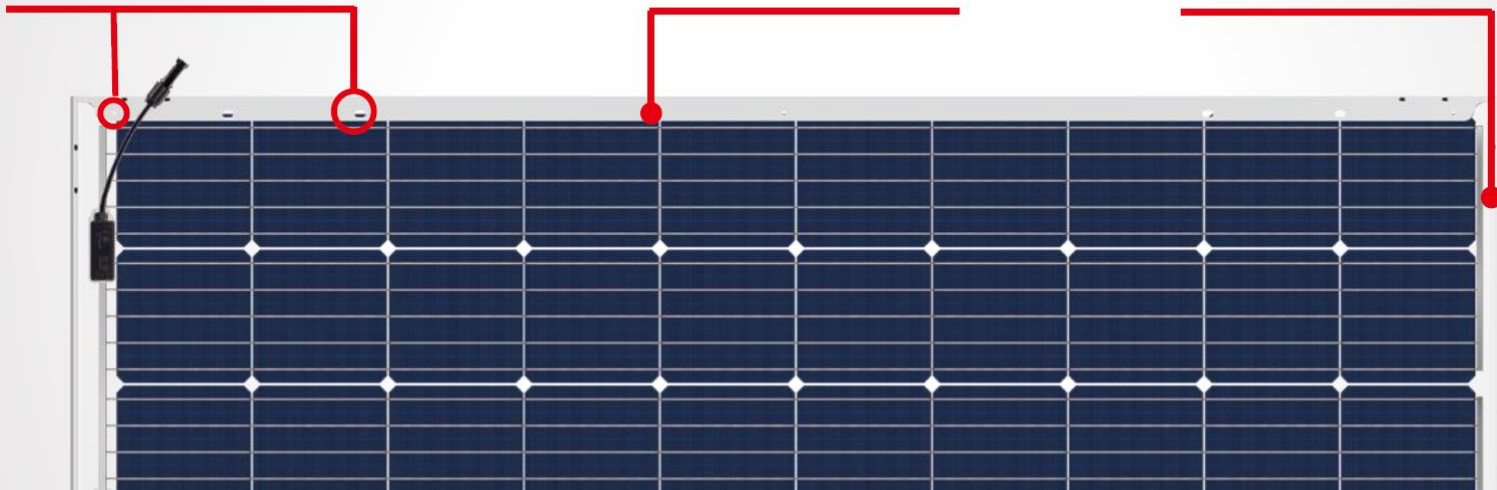
- Easy for transport and installation
- Modules can be electrical grounded

Higher Loading Performance

- Static Loading can reach 5400Pa
- Higher protection

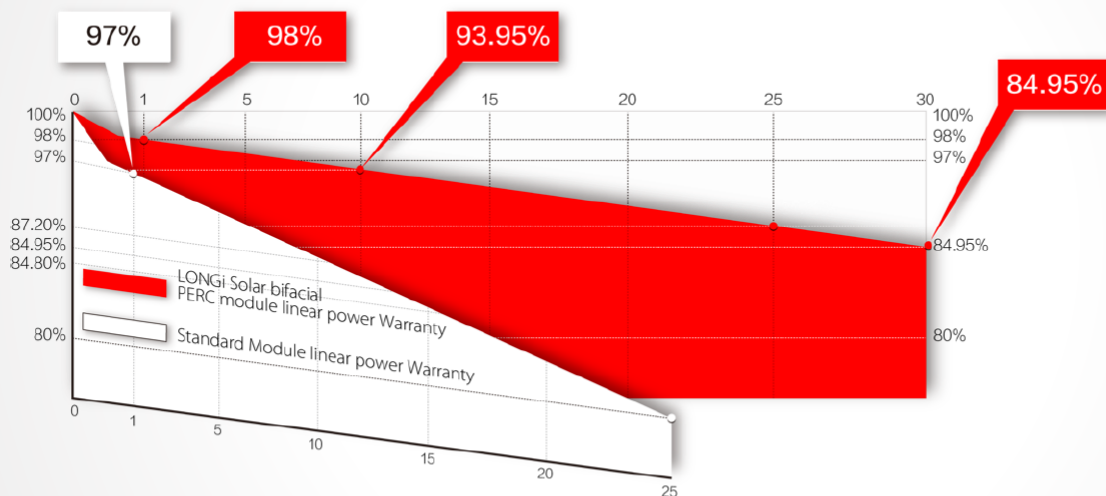
No shading on rear side

- Good design to avoid shading from rack and frame



- Bifacial Modules with frame can decrease the module breakage rate during transportation and installation
- Bifacial modules with aluminum frame can save labor cost and are compatible with tracker system

Bifacial Module Power Degradation Warranty



WARRANTY

10Y MATERIAL & CRAFTWORK

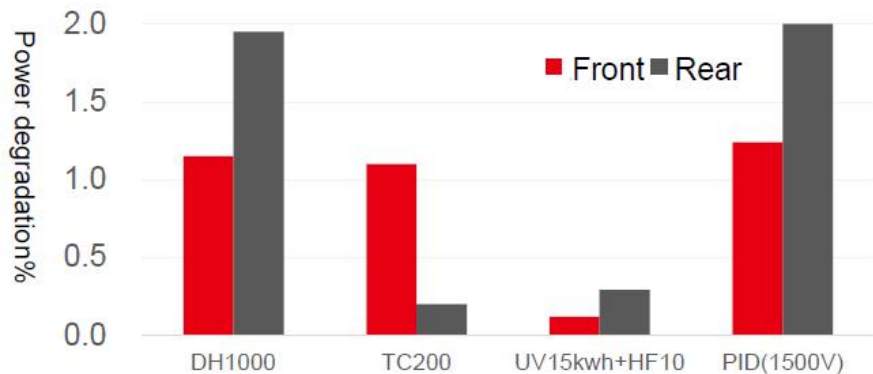
10Y POWER-OUTPUT > 93.95%

30Y POWER-OUTPUT > 84.95%

1st year degradation < 2%, 0.45% annually through 30 years

POE encapsulation

- Better material stability than EVA
- High body resistivity, low moisture transmission rate
- High long-term reliability, especially improve rear anti-PID performance



Optimize System Design to Improve Bifacial **Energy Yield**

System Design with Bifacial Module

Main Parameters to consider:

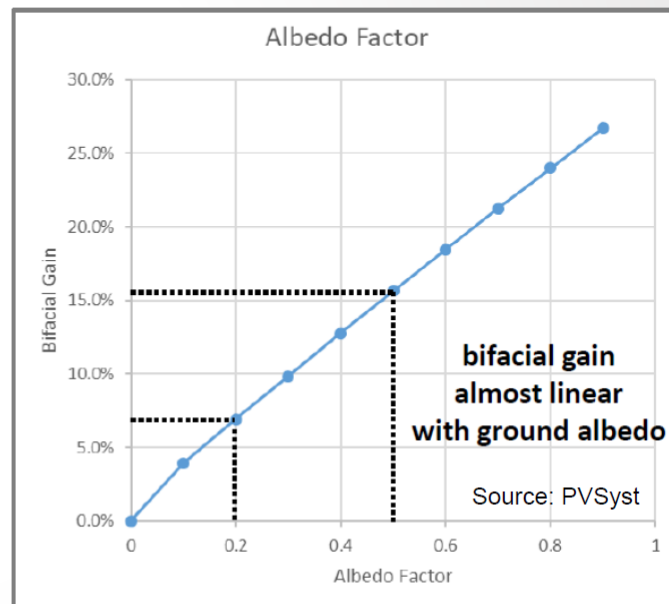
Albedo	↗
Clearance/height	↗
Racking	No backside shading
Row spacing (GCR)	(↗ ↘)
Inverter DC/AC ratio	↘



Backside Energy Yield: **Albedo**

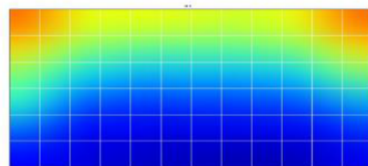
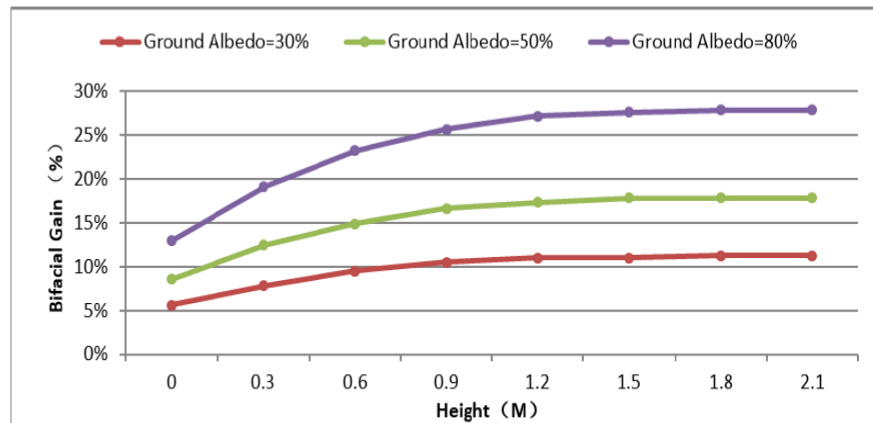
Bifacial gain improves with increasing ground Albedo

Ground condition	Reflectivity
Grassland	0.15~0.25
New grass	0.26
New snow	0.82
Dry asphalt	0.09~0.15
Wet asphalt	0.18
Dry sand	0.2-35
Cement	0.25~0.35
Red tiles	0.33

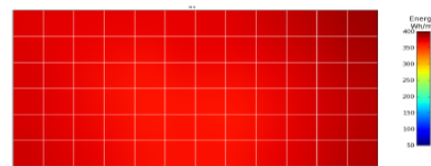


Backside Energy Yield: **Albedo and Height**

- Bifacial module backside energy yield improves with increasing Albedo (background reflectivity). Selecting site with more reflective background can improve overall system energy yield
- Increasing module height improves backside energy yield, as well as backside irradiance uniformity
- Module height (clearance from ground) of 1m and above is recommended

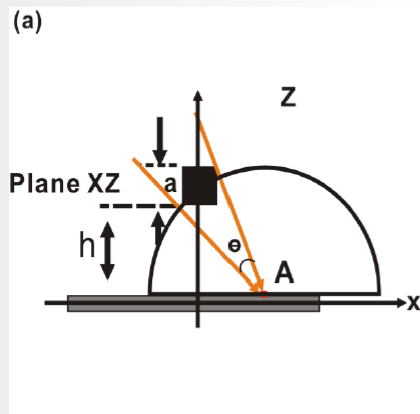


Irradiance at backside - Clearance 8 cm

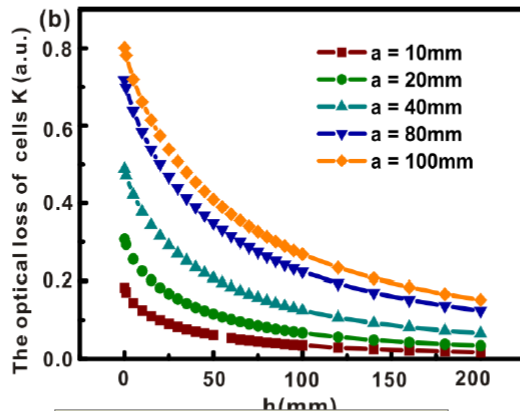


Irradiance at backside - Clearance 108 cm

Bifacial System Design: Shading Impact

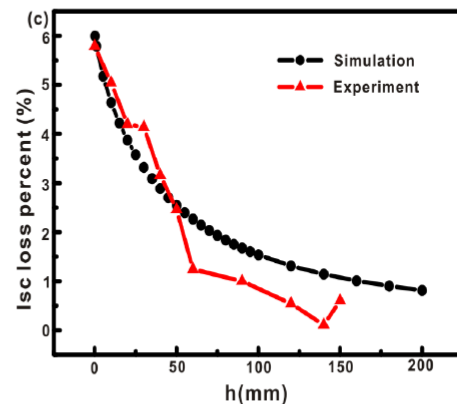


Simulation Result of Optical Loss with Rack Clearance and Thickness

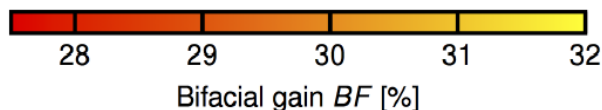
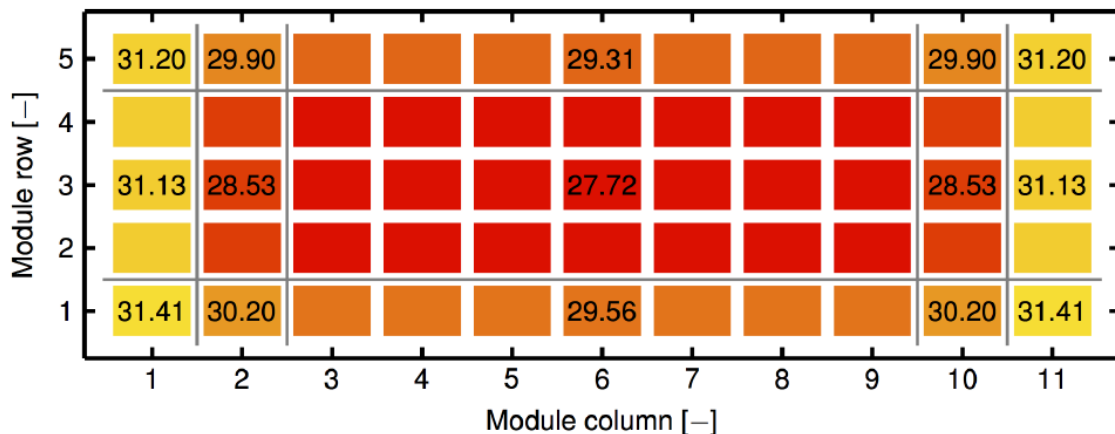


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Field Test Result and Simulation Result Comparison



- Based on the simulation result, increasing the rack clearance or decreasing the rack thickness can reduce optical loss
- Field measurement matches simulation result well
- If backside rack shading is unavoidable, setting the rack clearance larger than 40mm is highly recommended



$$\alpha = 0.5$$

$$d_R = 2.5 \text{ m}$$

$$h_M = 1.5 \text{ m}$$

- Bifacial gain depending on the module with lowest performance = lowest irradiation
- Modules in the Edge of the array can “see” more light = higher irradiation
- Electrical connection is key to obtain the maximum Benefit = losses reduction

Single Module:

$BF = 34 \%$

Module field:

$BF = 27.72 \%$ (worst)

$BF = 31.41 \%$ (best)

Electrical Characteristics											
Model Number	LR6-72BP-350M		LR6-72BP-355M		LR6-72BP-360M		LR6-72BP-365M		LR6-72BP-370M		
Testing Condition	Front	Back	Front	Back	Front	Back	Front	Back	Front	Back	
Maximum Power (Pmax/W)	350	263	355	267	360	271	365	274	370	278	
Open Circuit Voltage (Voc/V)	47.2	46.8	47.4	47.0	47.6	47.2	47.8	47.4	47.9	47.5	
Short Circuit Current (Isc/A)	9.39	7.19	9.48	7.26	9.58	7.34	9.66	7.40	9.77	7.49	
Voltage at Maximum Power (Vmp/V)	39.2	40.2	39.4	40.4	39.5	40.5	39.7	40.7	39.8	40.8	
Current at Maximum Power (Imp/A)	8.93	6.54	9.02	6.62	9.11	6.69	9.19	6.73	9.30	6.82	
Module Efficiency(%)	17.8	13.3	18.0	13.5	18.3	13.7	18.5	13.9	18.8	14.1	
STC (Standard Testing Conditions): Irradiance 1000W/m ² , Cell Temperature 25 °C, Spectra at AM1.5											

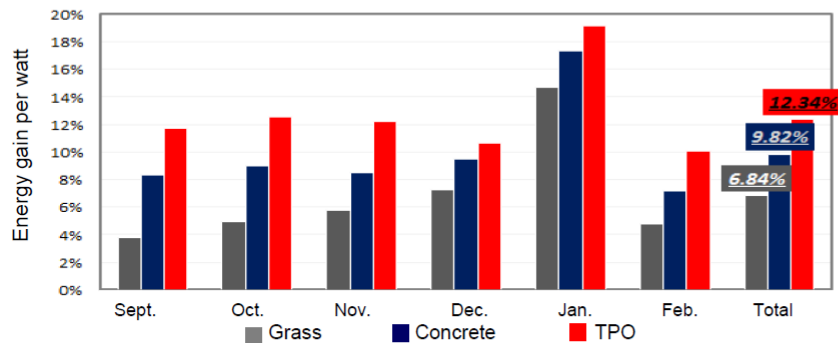
Electrical characteristics with different rear side power gain (reference to 360W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
378	47.6	9.98	39.5	9.57	5%
396	47.6	10.45	39.5	10.03	10%
432	47.7	11.39	39.4	10.97	20%
450	47.7	11.87	39.4	11.43	25%

- Size the electrical components taking into account the rear gain
- i.e. For a 360W with a rear side power gain of 10%
- Consider inverter clipping or derating due to the extra power

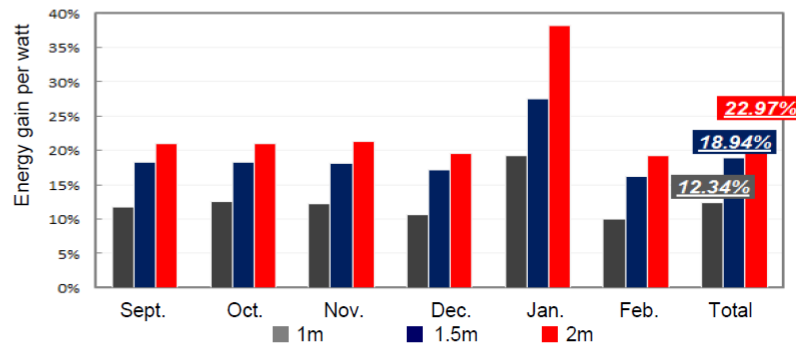
Bifacial PERC Module Field Monitoring Data

Energy yield comparison Bifacial vs. mono PERC



Energy yield gain at 1m racking height:
TPO(12.34%) > Concrete(9.82%) > Grass(6.84%)

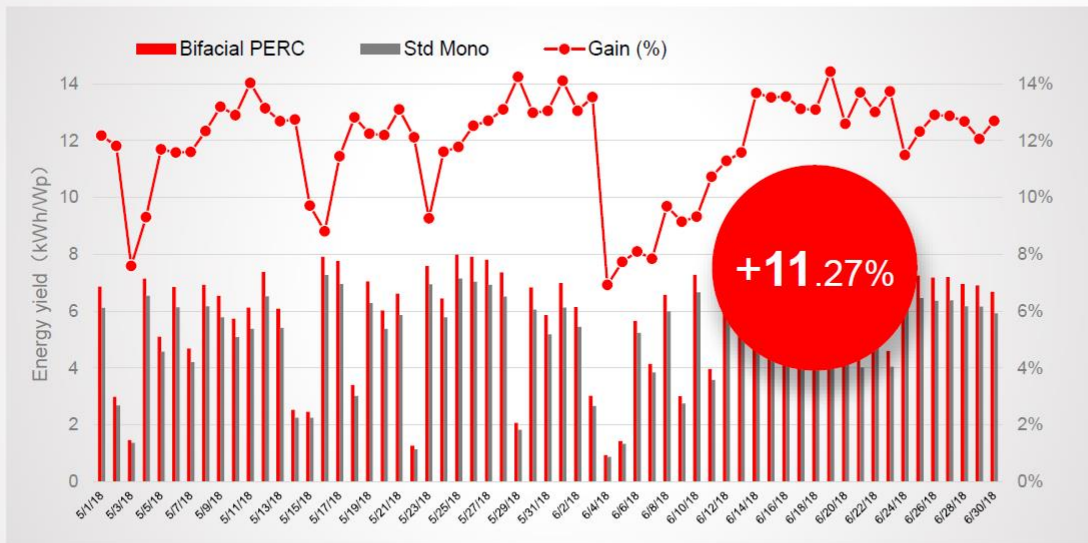
Energy yield comparison Bifacial vs. mono PERC



Taizhou test site (N32.5° / E119.9°)

Energy yield gain (TPO floor):
2m(22.97%) > 1.5m(18.94%) > 1m(12.34%)

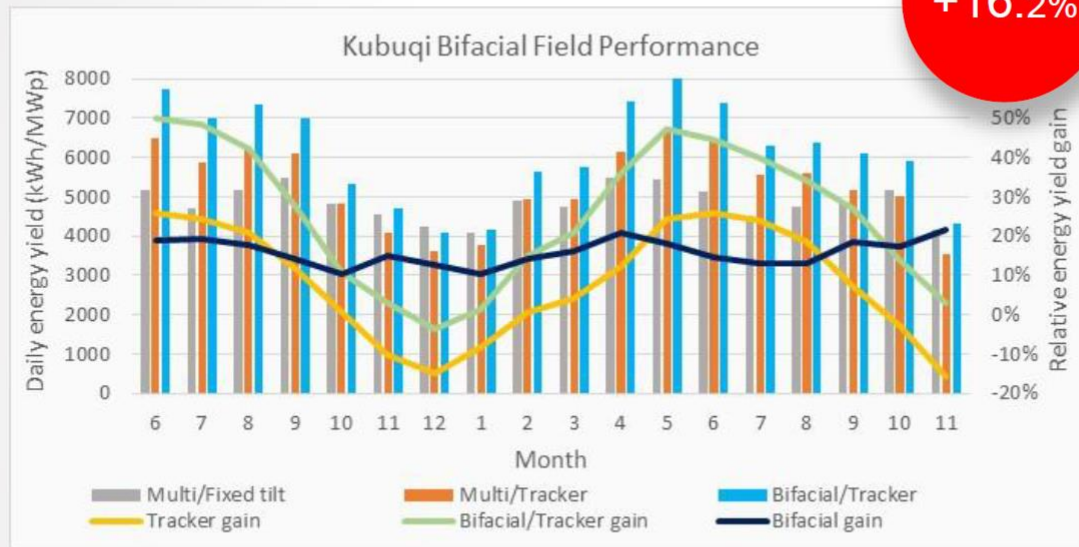
Bifacial PERC Module Field Monitoring Data



- Bifacial PERC Capacity 18.9kw, std. mono capacity 18.25kw, project located in Pucheng, Shaanxi (N34.97°/E109.59°), China
- Fixed tilt configuration (15 degree), distance to ground 1.6m
- Three month monitoring data showed 11.27% energy yield from backside

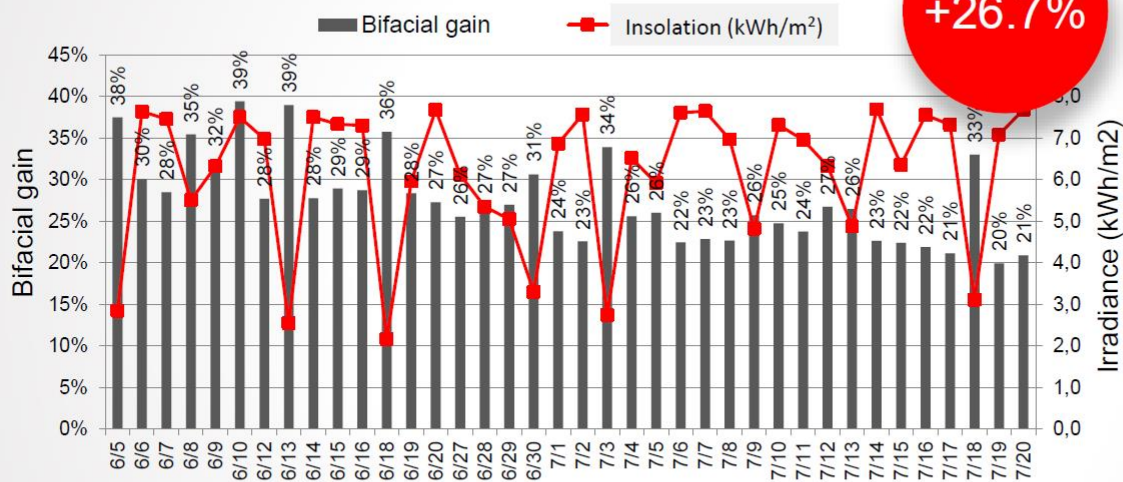
Bifacial PERC Module Field Monitoring Data

+16.2%



- Bifacial PERC project (336kw on single axis tracker) in Kubuchi, Inner Mongolia (N45.36°/E118.36°), China
- 18 month energy yield by Bifacial module + tracker is 26.6% higher than Multi module/fixed tilt and 16.2% higher than Multi/tracker

Bifacial PERC Module Field Monitoring Data

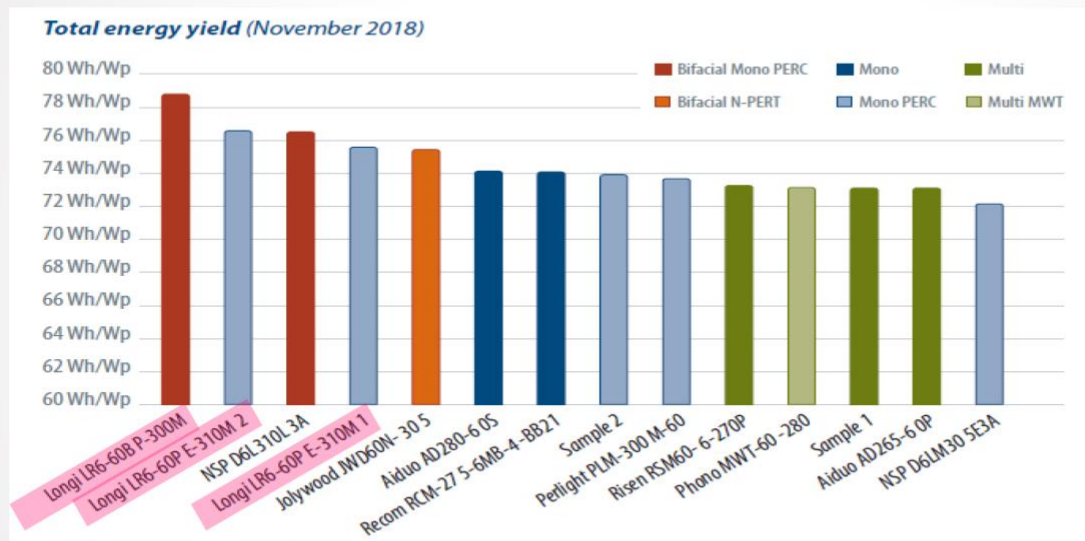


+26.7%



- Location: Turpan (N42.87/E89.4); testing period: 6/5/2018 – 7/20/2018
- Fixed tilt (40°), ground condition: concrete with white paint
- There is more scattered light under low irradiance condition, thus bifacial energy gain is higher with lower irradiance

PV Magazine Outdoor Test



- In general, Mono PERC and Bifacial PERC modules showed better energy yield than Multi modules
- LONGi Bifacial PERC module demonstrated the best energy yield among all modules
- LONGi Mono PERC modules showed similar performance as Bifacial modules from other suppliers, superior among all PERC modules

HIGH POWER – BOS SAVINGS and LCOE Improvement

Use of high efficiency mono/PERC module,
BOS COST SAVINGS can be realized with reduced use of

Land



Racking



Cables



Earth/concrete
work



Labor





Thank You for Your Attention

乐叶光伏科技有限公司

地址：陕西省西安经济技术开发区尚稷路8989号B座

电话：4009696199

LONGi Solar

Block B, No.8989 Shangji Road, Xi'an Economic and Technology Development Zone, Xi
Shaanxi, China

TEL: +86-4009696199

JUAN CARLOS GONZALEZ – jc.gonzalez@longi-solar.de +34 616423467