

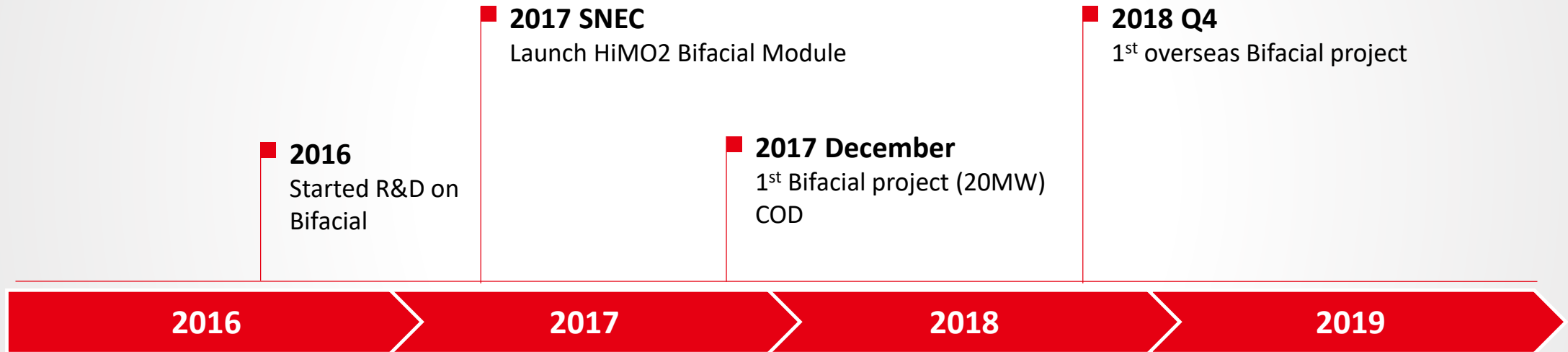
LONGI Solar

Realize Full Potential of Bifacial PERC Technology

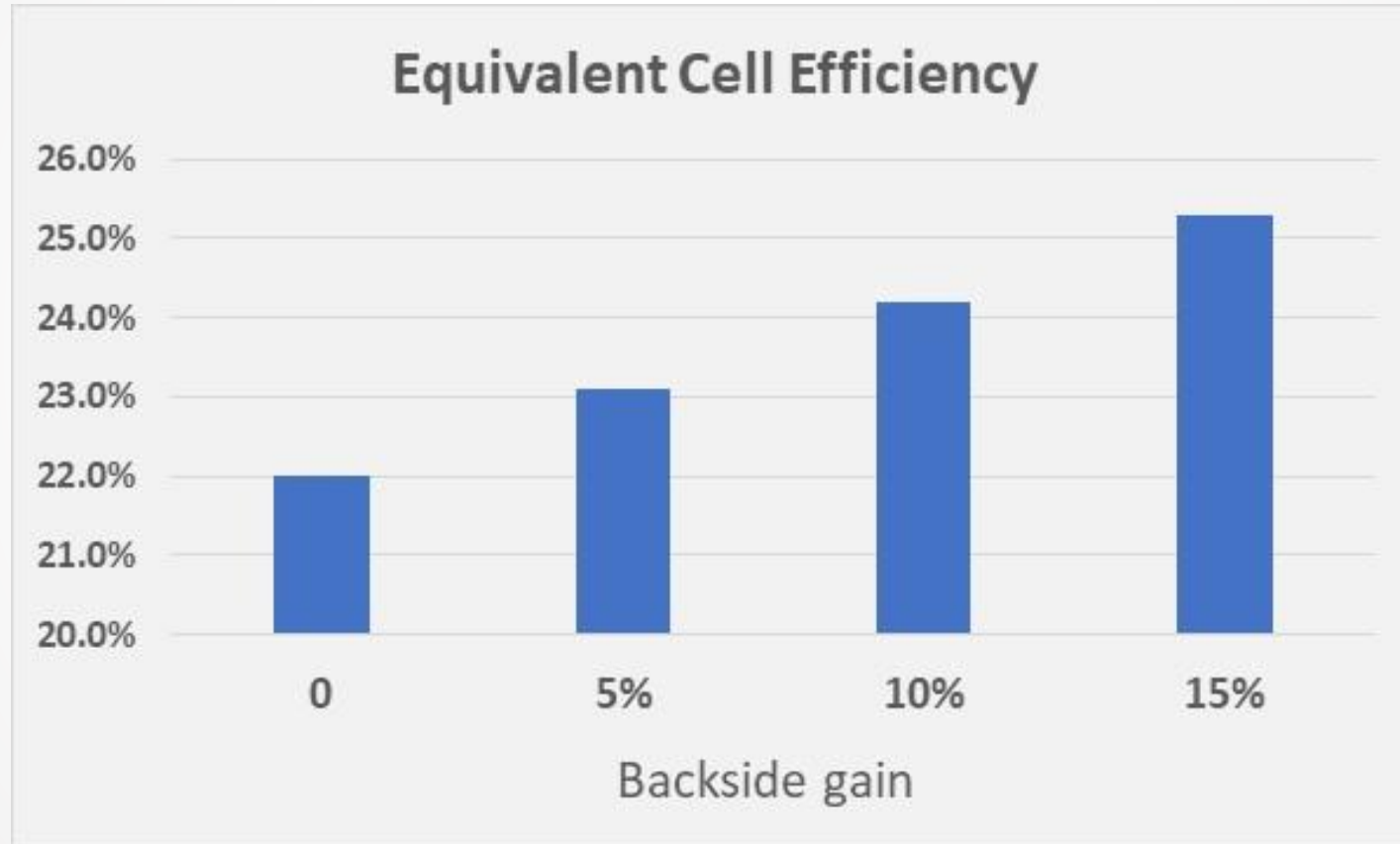


Hongbin Fang
Director of Product and Technology
Amsterdam, Netherlands
September 16, 2019

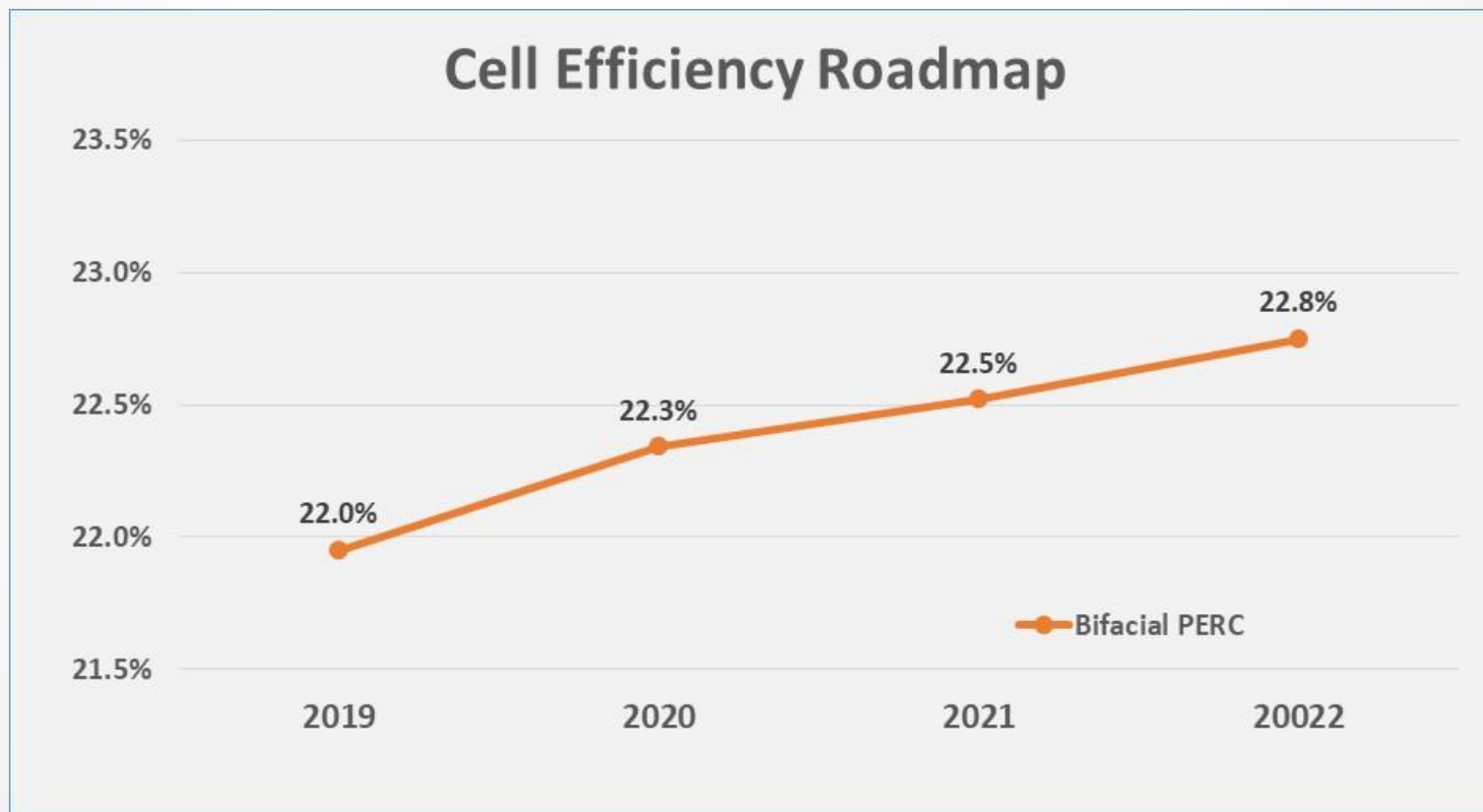
Bifacial PERC at LONGi



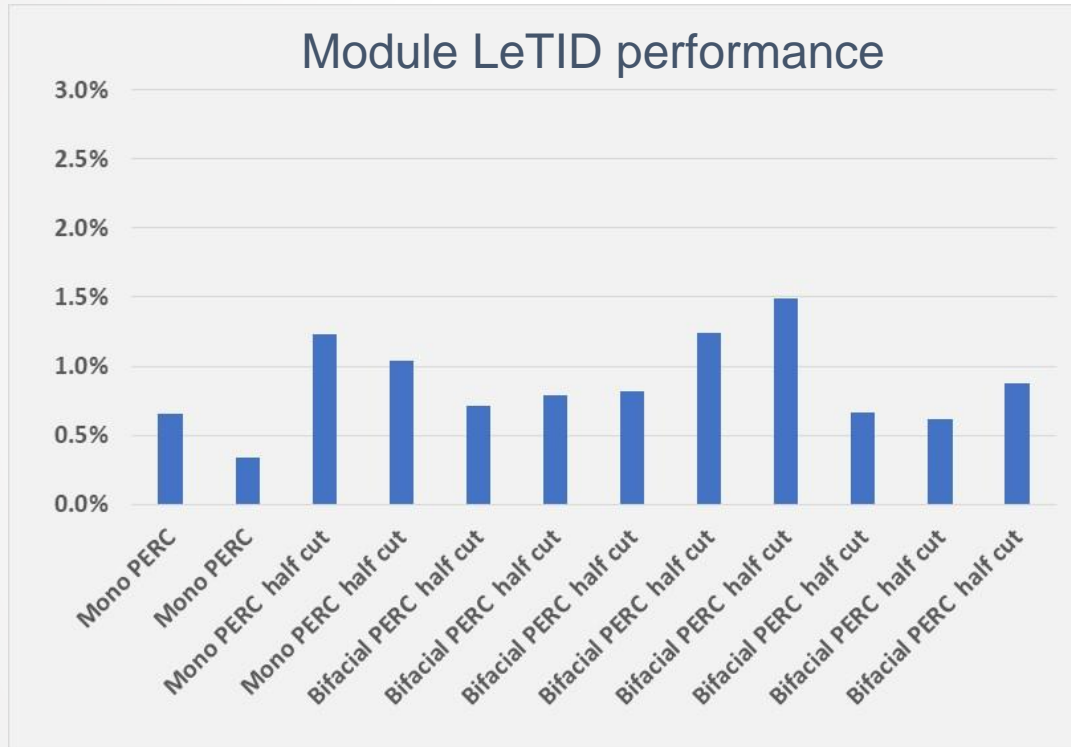
Bifacial PERC: another way to improve efficiency



Improve Cell Efficiency



Control Power Degradation

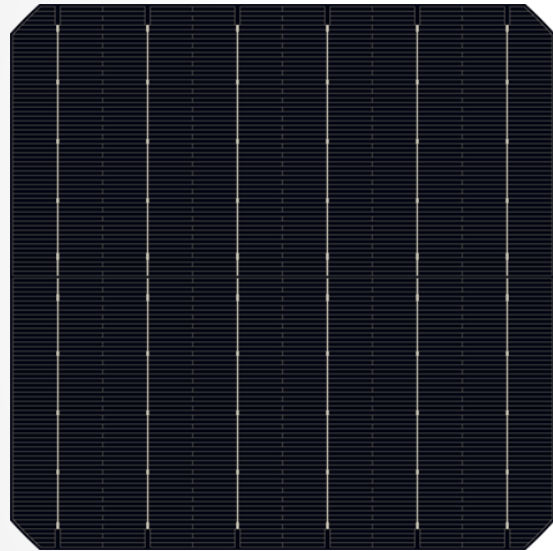


3rd party LeTID testing results at 75C

- LeTID is generally believed to be related to metal impurity and H defect in the wafer substrate
- LONGi Solar, as integrated ingot/wafer/cell/module manufacturer, has tackled this issue from multiple directions: improve wafer quality and optimize cell processes

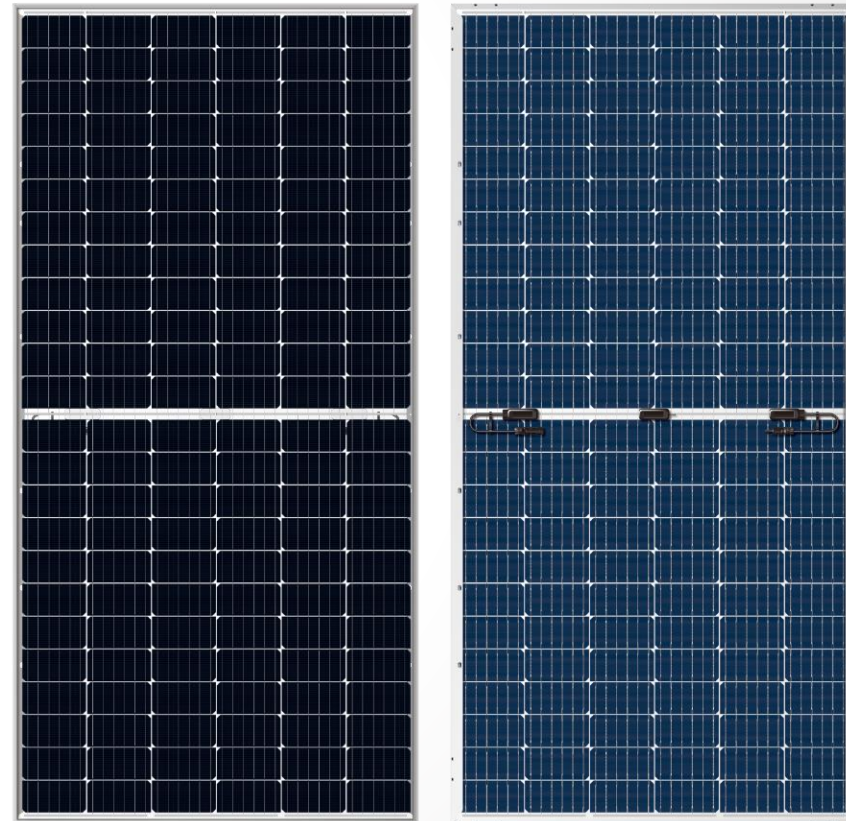
Hi-MO4: Bifacial Module with Power up to 440W

Cell w/ M6 wafer
(166mm)



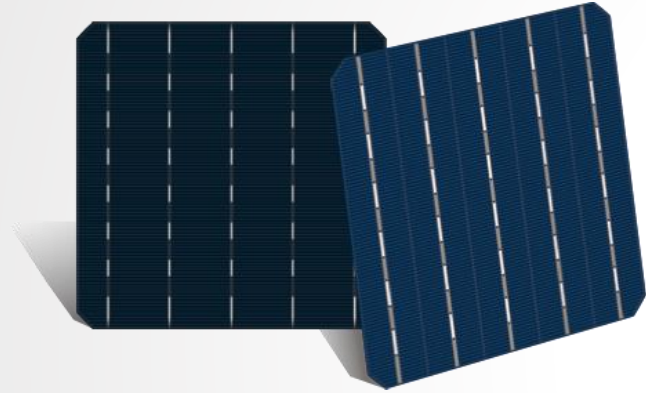
- ✓ Upgraded Bifacial PERC technology
- ✓ Efficiency up to 22.5%
- ✓ 6 busbars
- ✓ Better light reception

Module

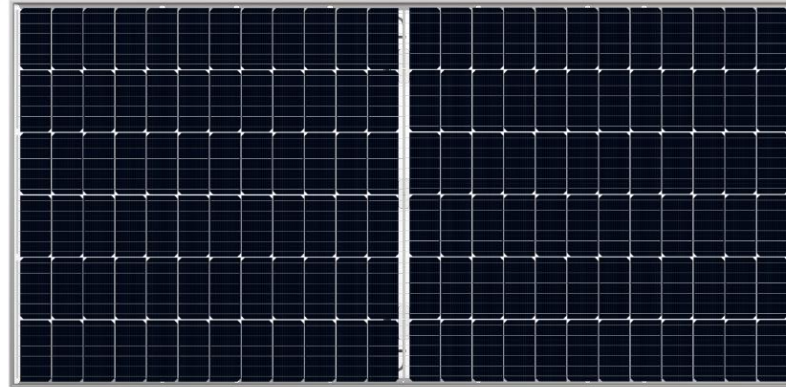


Front power up to 440W

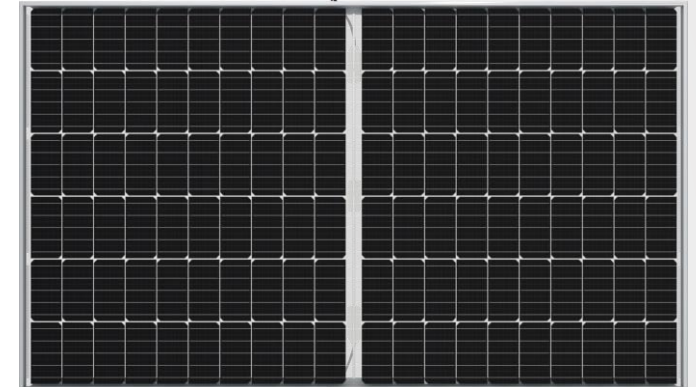
Mono/Bifacial PERC Efficiency Record



Cell Efficiency
24.06%



72-Cell Module Power
450.4W



Module Efficiency
20.83%

🕒 Jan. 2019

🕒 Apr. 2019

🕒 Nov. 2018

Optimize Bifacial Module Design

JBox outside active cell area

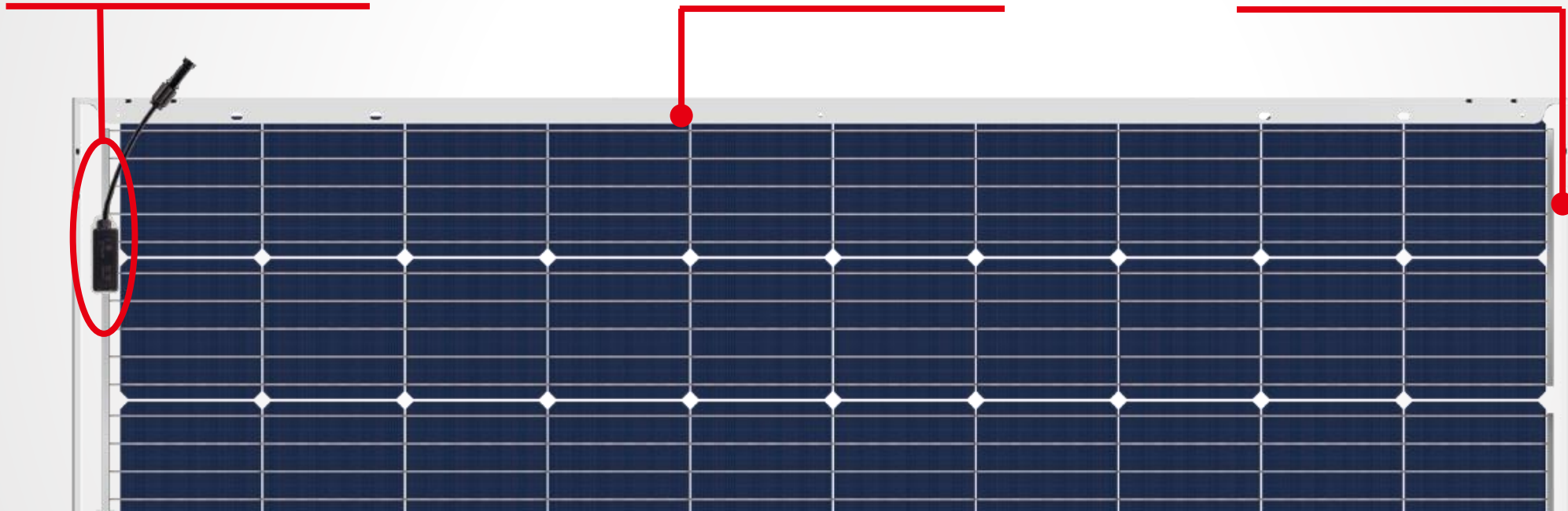
- Minimize backside shading from JBox

Higher Loading Performance

- Static Loading can reach 5400Pa
- Higher protection

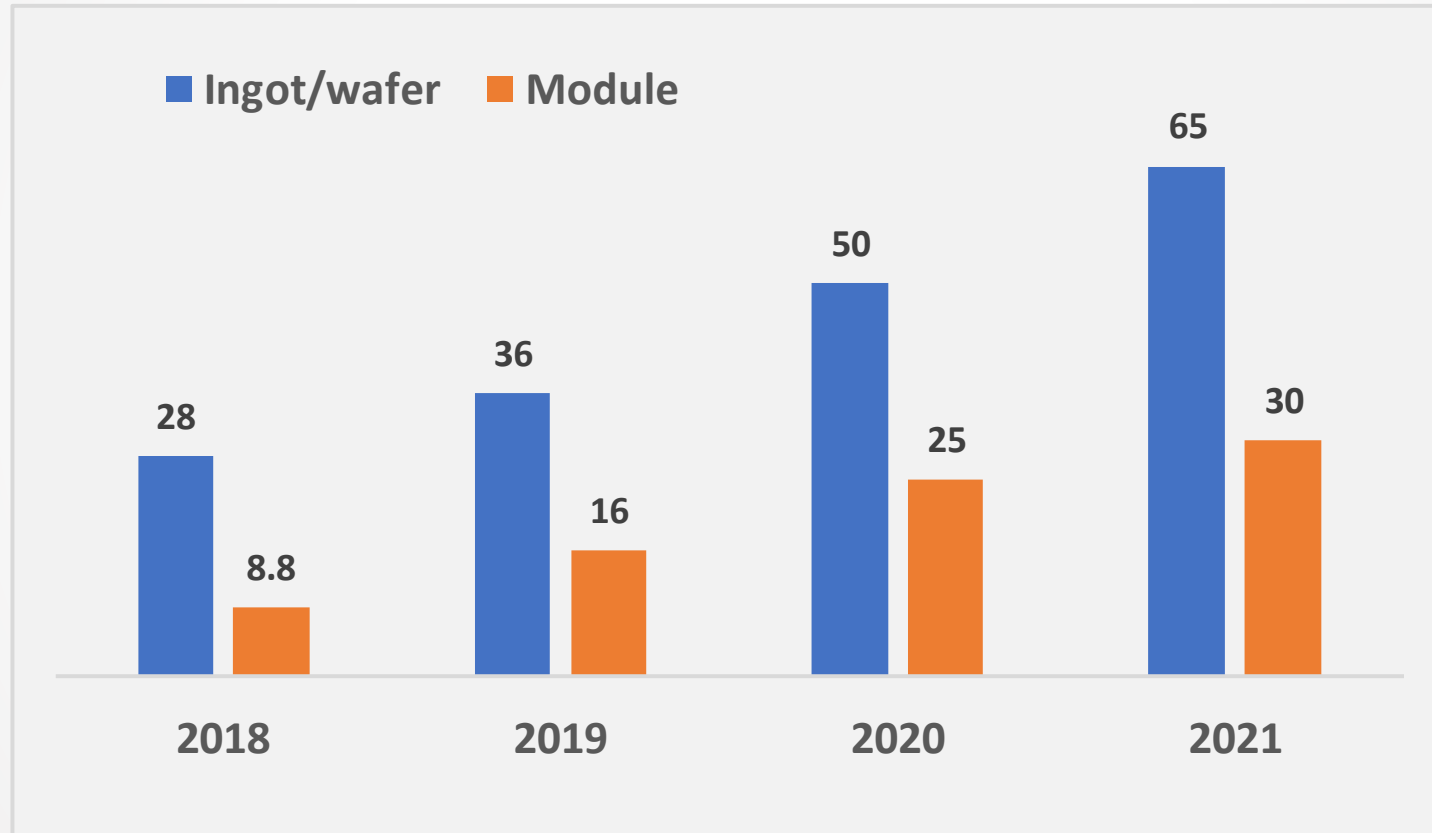
No C surface on short edge frame

- Minimize backside shading from frame



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

LONGi Manufacturing Capacity (GW)



Bifacial Technology is not only about Module

Racking/tracker

Main Parameters to consider:

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



Storage

Inverter

System integration plays a key role in improving bifacial gain

Backside Energy Yield: **Albedo**

Bifacial gain improves with increasing ground Albedo



Dry Sand
Albedo:
0.2-0.35



Grassland
Albedo:
0.26



Cement
Albedo:
0.25-0.35



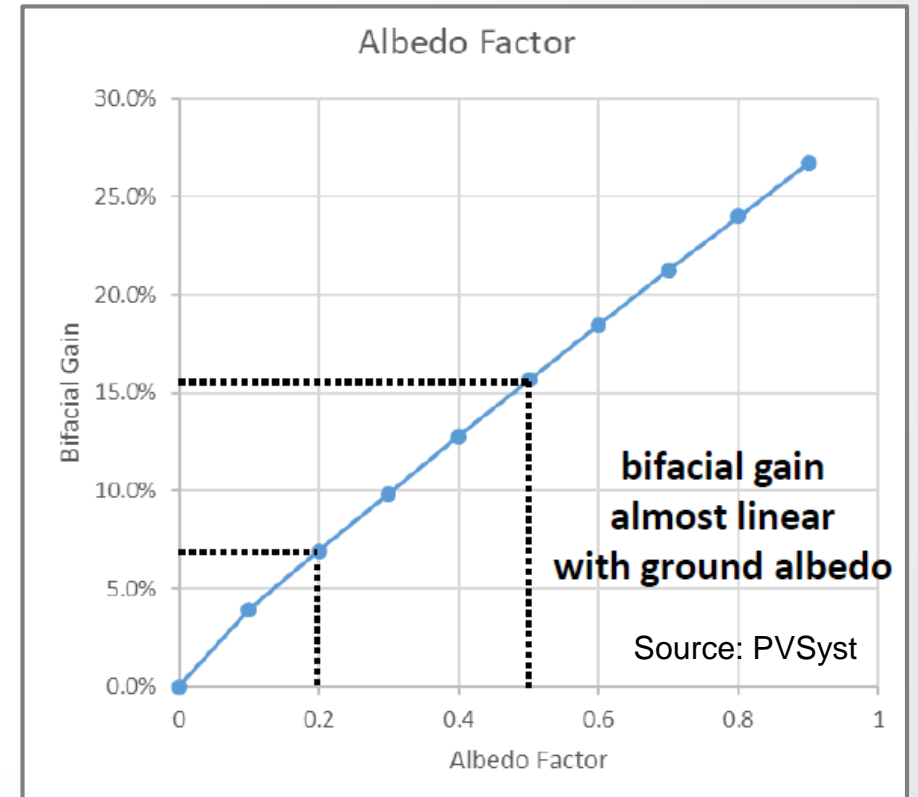
New Snow
Albedo:
0.82



Red Tiles
Albedo:
0.33

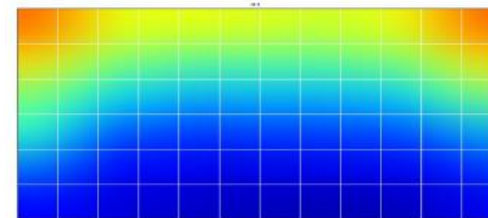
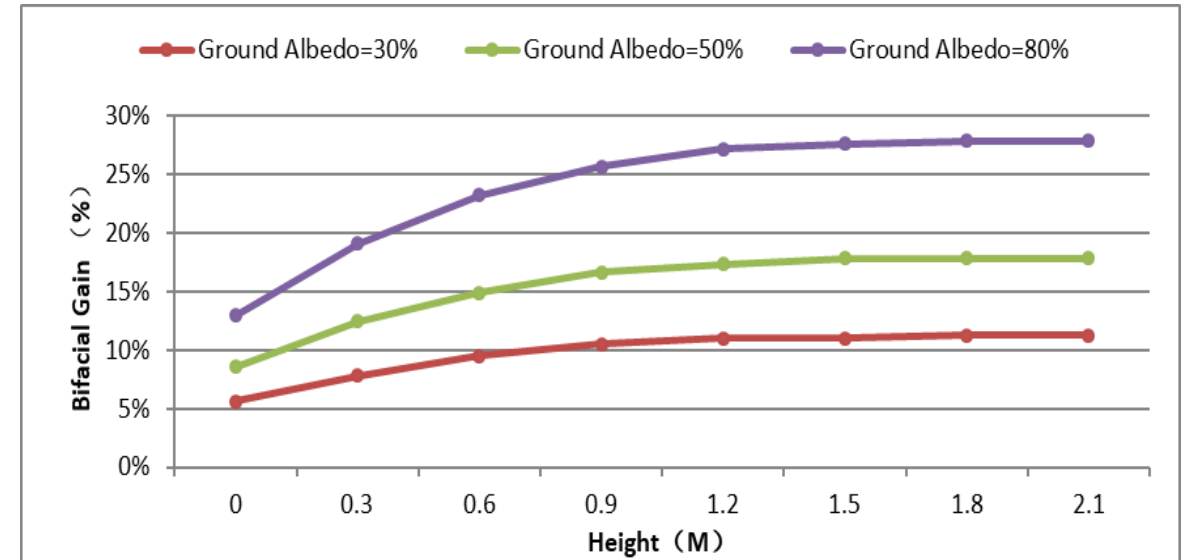


Dry asphalt
Albedo:
0.09-0.15

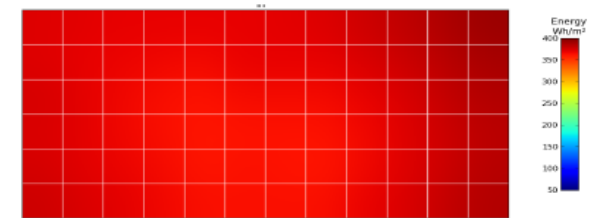


Backside Energy Yield: Albedo and Height

- 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

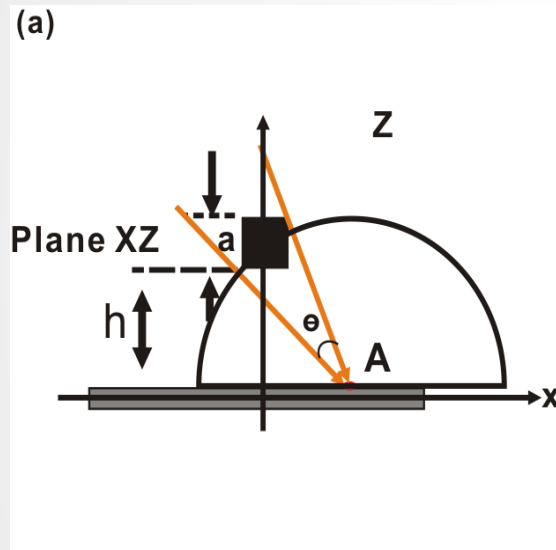


Irradiance at backside - Clearance 8 cm

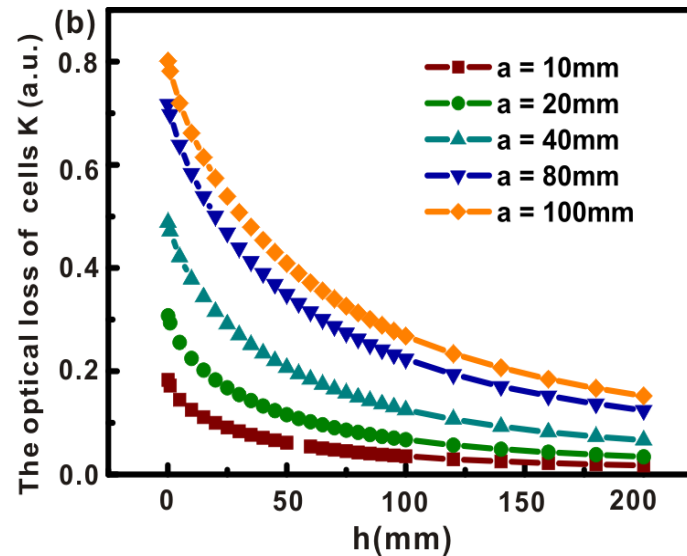


Irradiance at backside - Clearance 108 cm

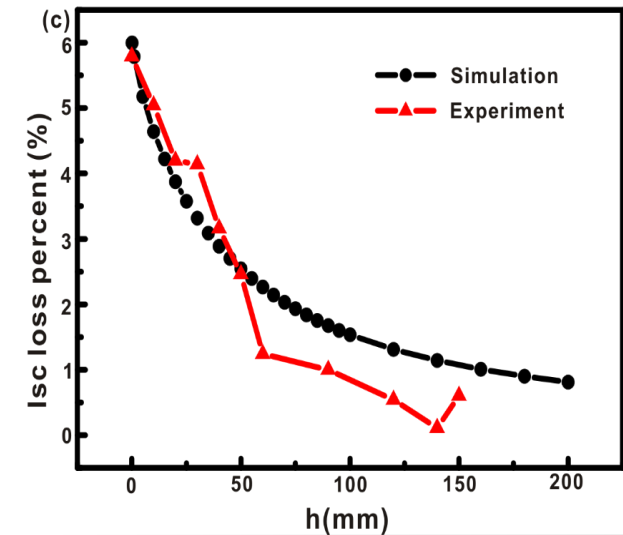
Bifacial System Design: Shading Impact



Simulation Result of Optical Loss with Rack Clearance and Thickness



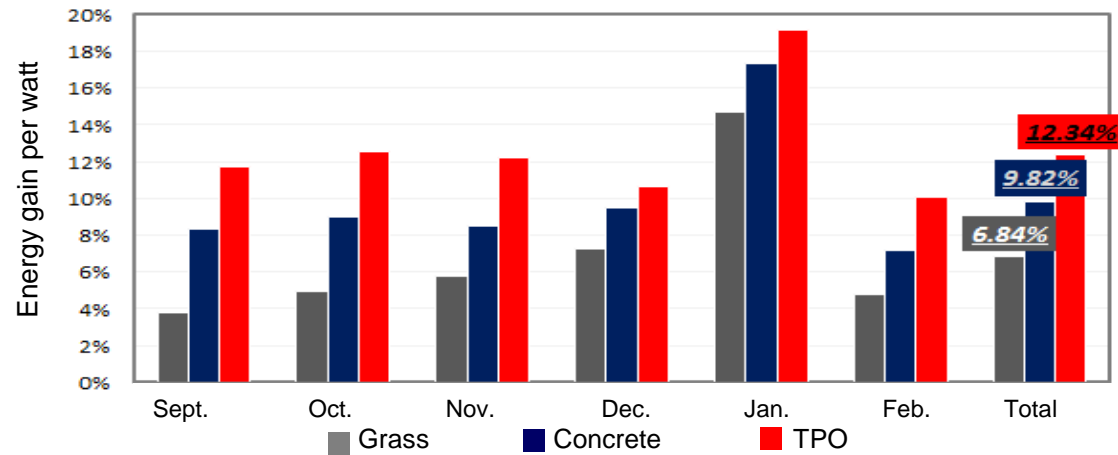
Field Test Result and Simulation Result Comparison



- 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

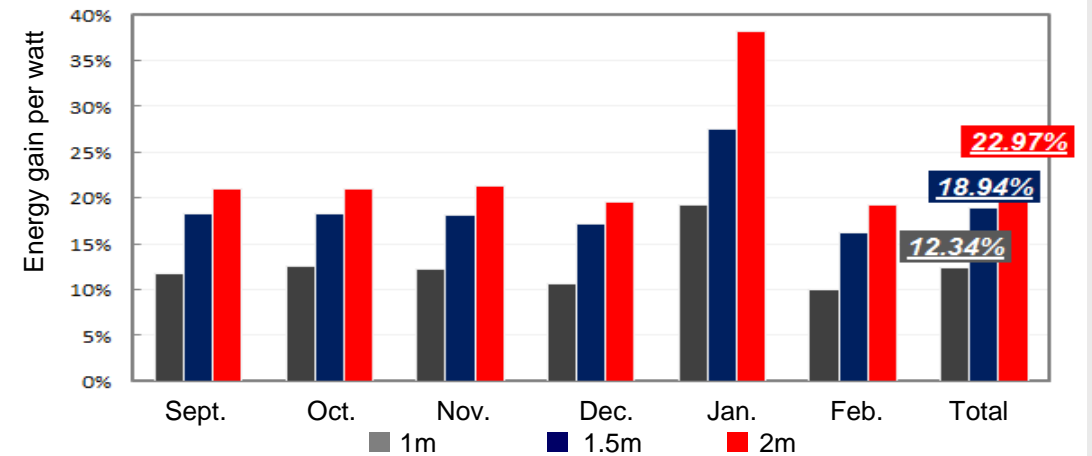
Bifacial PERC Module Field Monitoring Data

Energy yield comparison Bifacial vs. mono PERC



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

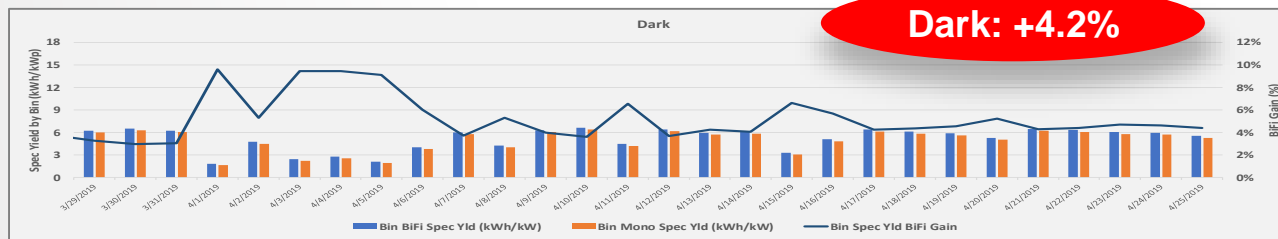
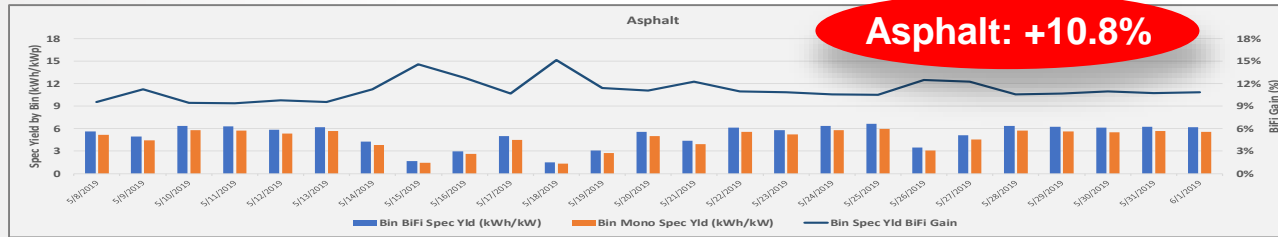
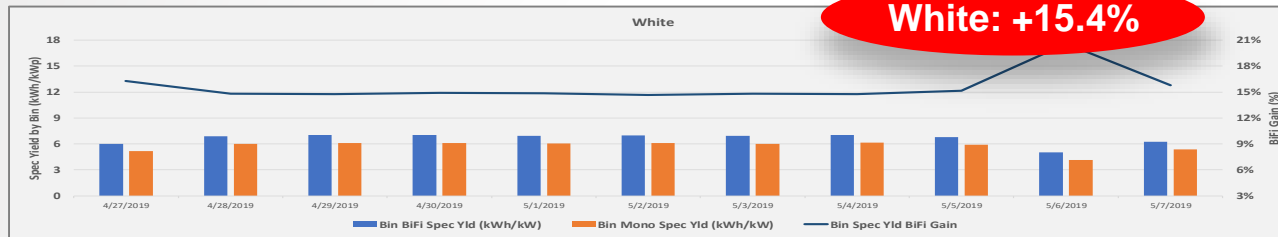
Energy yield comparison Bifacial vs. mono PERC



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

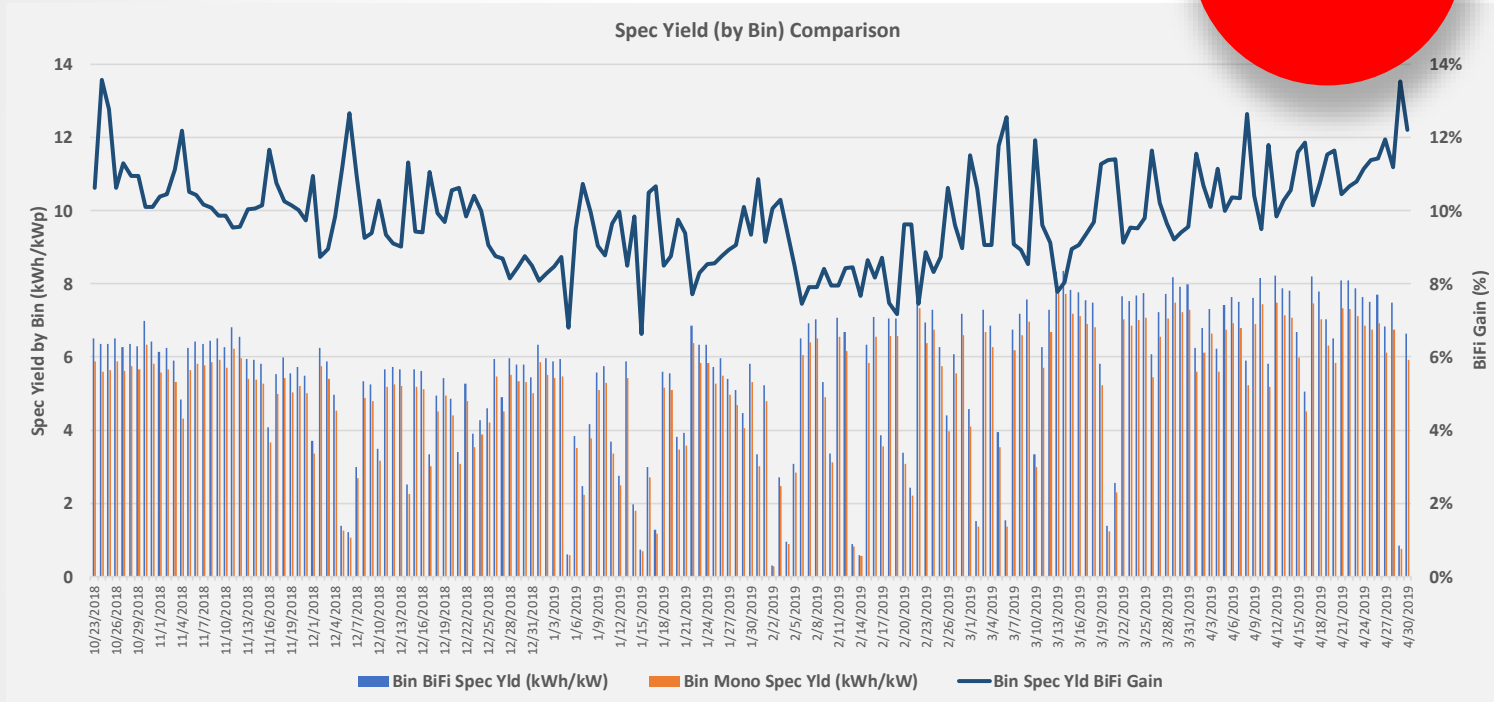


Site	Fremont, CA
Sample Size	5 Mono + 5 BiFi
Mounting Type	Fixed Tilt
Surface Type	White: Albedo 60.5% Asphalt: Albedo 22.9% Dark: Albedo 7.6%
Data Resolution	Module-level (via DC Optimizer)

- 5 modules **fixed tilt** system established and monitored by 3rd party lab RETC/B&V in California (N37.5, W122.0)
- **Bifacial gain correlates to surface Albedo:**
 - White/Asphalt/Dark rooftop, Albedo 60.5%/22.9%/7.6%
 - White/Asphalt/Dark rooftop, bifacial gain 15.4%/10.8%/4.2%

Bifacial PERC Module Field Monitoring Data

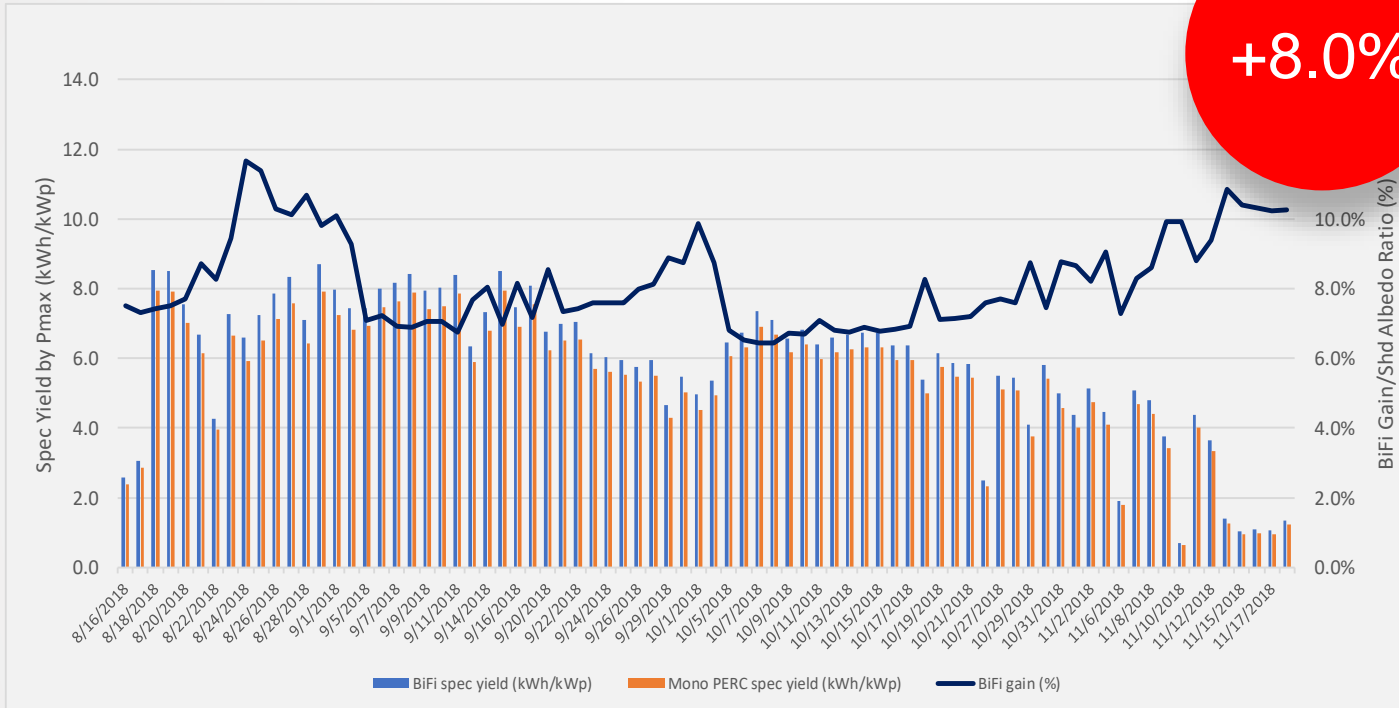
+9.8%



Site	Pahrump, NV
Sample Size	8 Mono + 8 BiFi
Mounting Type	Fixed Tilt, 1m clearance
Surface Type	White Gravel (Albedo 34.5%)
Data Resolution	String-level via Inverter

- 8 module **fixed tilt** system established and monitored by **3rd party lab RETC/B&V** in Nevada (N36.2, W116.0)
- Bifacial gain of 9.8% has been demonstrated with 6 months data acquisition

Bifacial PERC Module Field Monitoring Data

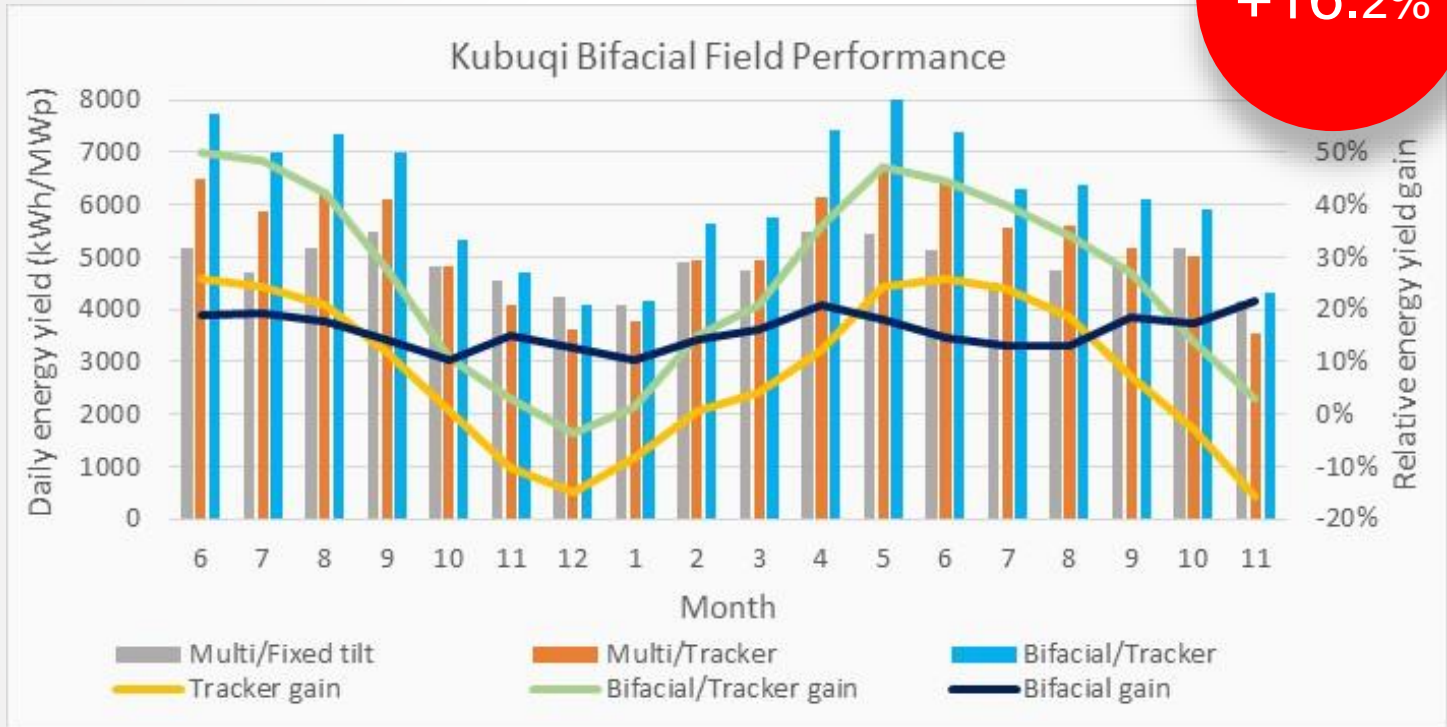


Site	Livermore, CA
Sample Size	6 Mono + 6 BiFi
Mounting Type	Single-Axis Tracker
Surface Type	Gravel
Data Resolution	Module-level (via DC Optimizer)

- 6 modules on **SAT** system established and monitored by 3rd party lab **RET/C/B&V** in California (N37.7, W121.7)
- Bifacial gain of 8.0% has been demonstrated with 3 months data acquisition

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

Summary

- Bifacial technology has been widely deployed globally
 - Bifacial PERC technology effectively achieved advanced n-type efficiency at p-type cost, offering competitive system economics
 - Significant backside energy yield has been demonstrated through field data collection
- To realize full potential of bifacial PERC technology
 - Cell efficiency and module power output will continue to improve
 - Module reliability and power degradation need to be controlled well
 - Continuous capacity expansion will ensure sufficient bifacial module supply
 - System integration plays a key role in improving bifacial gain

Bifacial PERC: Best Solution to Lower LCOE