The Most Efficient and Adaptable Solution Design for Bifacial Modules

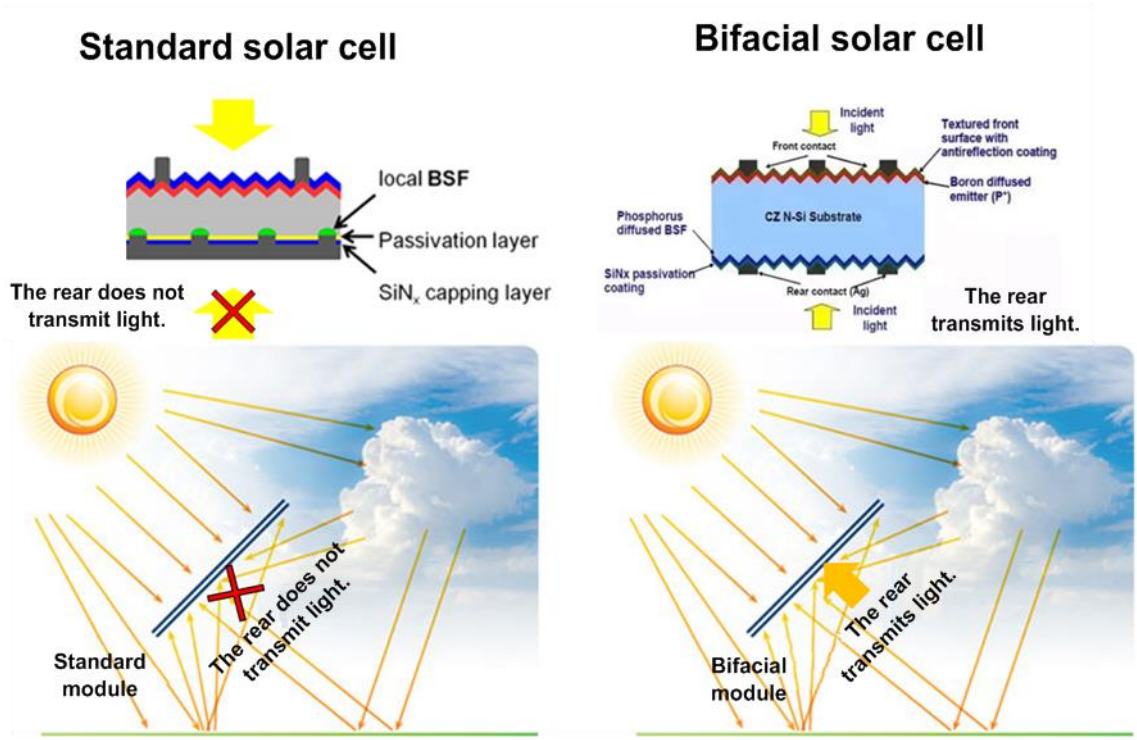
Introduction:

The highly efficient PV module technology that is widely used in the industry is a bifacial module. These efficient PV modules need to be used with devices such as inverters to maximize value. Recently, many inverters and solutions that match bifacial modules have appeared in the industry. Which solution is the best match for bifacial modules? Based on a large amount of experimental data, this article describes the solution needed by bifacial modules.

1 Bifacial Module

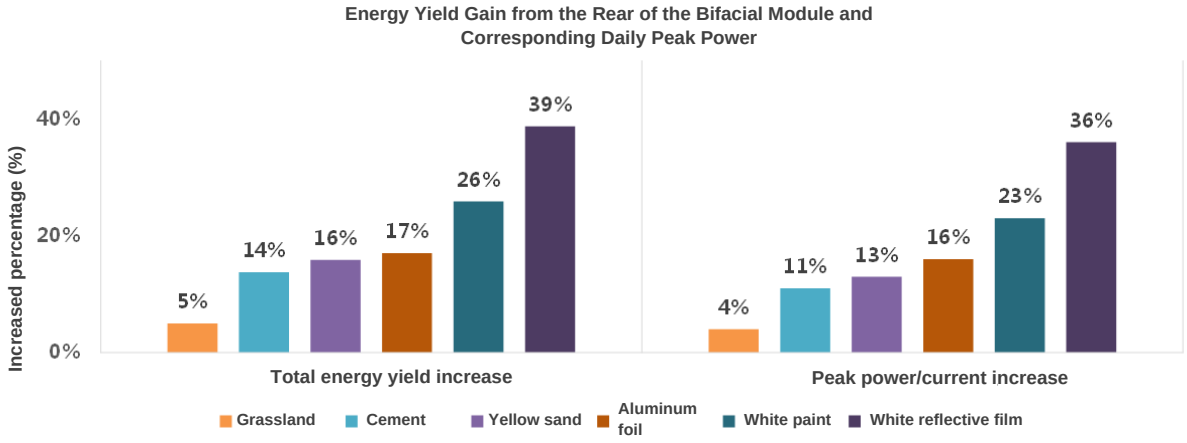
The solar cell technologies used by bifacial solar modules which are currently on the market include the PERC technology based on the p-type silicon wafer, the PERT technology based on the n-type silicon wafer, and the HIT technology of heterogeneous structures.

Figure 1-1 Standard PV module and bifacial module



As shown in Figure 1-1, in addition to receiving solar radiation from the front, the rear of the bifacial module can also receive scattered light from the air, reflection light of the ground, and direct solar light coming from the rear during the morning and evening. Therefore, the power generated by the bifacial module is greater compared with the standard PV module designed for the same PV plant.

Figure 1-2 Energy yield gain from the rear of the bifacial module



We have tested standard and bifacial modules with the same structure for a long time. As shown in the figure, the energy yield gain from the rear of the bifacial module varies depending on the scenario, and the energy yield increases by 5%–39%. In addition, the bifacial module can further increase the energy yield by 2%–6% based on its excellent performance of good response to low light and low power loss under the working temperature.

Generally, the energy yield gain of a bifacial module compared to a standard PV module is about 7%–45% in the scenarios listed in Figure 1-2.

2 What Solution Does a PV Plant with Bifacial Modules Need?

2.1 the Solution Configures Higher Input Current and Higher Efficiency Inverters

The following table lists some parameters of the bifacial module with the power of 300 W on the front side from a well-known vendor. As the bifacial module gain increases, the open-circuit voltage and peak power voltage remain unchanged, while the peak power and peak power current of the PV module increase. In this case, designers need to select a more appropriate inverter with a larger DC input current based on the actual gain.

Table 2-1 Parameters of a bifacial module

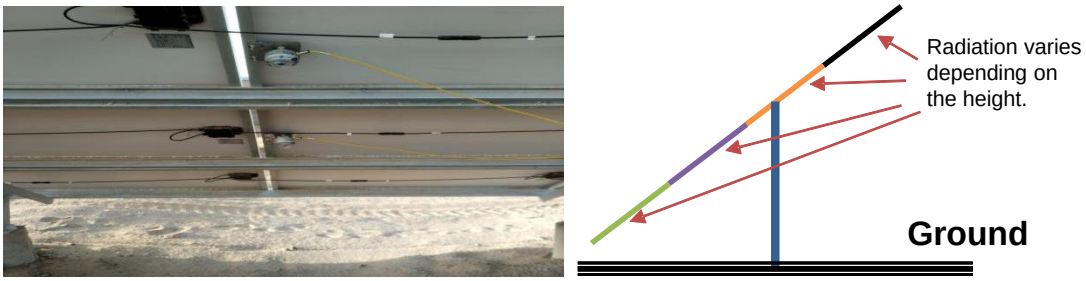
	PV Module Peak Power (W)	Open-circuit Voltage (V)	Peak Power Voltage (V)	Peak Power Current (A)
Standard PV module	300	39.6	32.9	**9.11**
Bifacial module gain (5%)	315	39.6	32.9	**9.58**
Bifacial module gain (10%)	330	39.6	32.9	**10.04**
Bifacial module gain (20%)	360	39.7	32.8	**10.98**

	PV Module Peak Power (W)	Open-circuit Voltage (V)	Peak Power Voltage (V)	Peak Power Current (A)
Bifacial module gain (25%)	375	39.7	32.8	**11.44**

The upcoming Huawei string inverter for MENA market can fully meet the requirements for the increase of the output current of the bifacial module.

2.2 Finer MPPT Granularity

Figure 2-1 Rear gain of a bifacial module varies greatly depending on the position

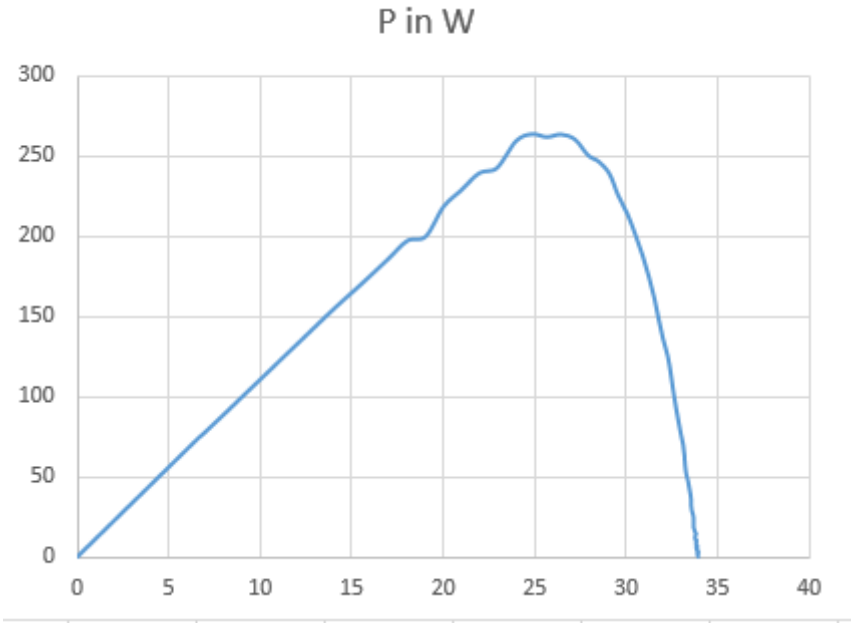


As shown in Figure 2-1, the rear radiation of the bifacial module is uneven. As a result, the overall output power of the PV module is different, and the current discrete rate of the PV module reaches more than 5%. In this case, the MPPT granularity of inverters should be finer. In addition, the mismatch loss caused by inconsistency should be avoided when the string is designed and when it connects to inverters.

Every two strings connected to Huawei upcoming string inverter dedicated for bifacial modules form one MPPT circuit, which means that the inverter has the finest MPPT granularity in the industry. This minimizes the mismatch caused by bifacial modules. Based on PVSYST simulation, it is found that the mismatch loss caused by inverters which form one MPPT circuit by every two strings is lower than that caused by common inverters in the bifacial module system.

2.3 Highly Adaptive and the Most Accurate and Efficient MPPT Algorithm in the Industry

Figure 2-2 P-V curve of the PV module



As shown in Figure 2-2, since the mismatch of the bifacial module is high, its P-V curve is more complex than that of the standard PV module, and its power-voltage curve will generate multiple peak values. This poses higher requirements on the detection precision and MPPT of inverters.

Huawei string inverters have multiple MPPT units, which can greatly avoid energy yield loss caused by string mismatch. The detection precision of a string reaches 0.5%. In addition, Huawei inverter uses the most efficient MPP intelligent tracking algorithm in the industry. The inverter adopts the adaptive MPPT technology. When the irradiance is stable, the maximum power point of the PV module can almost be reached. When the irradiance rapidly changes in cloudy weather, the inverter can quickly respond and track the maximum power point in real time, so it can adapt to the bifacial module properly.

In addition, as the bifacial module has multiple peak values, the inverter can intelligently identify whether the maximum power point has been reached. The high-speed multi-peak scanning algorithm is enabled to ensure that the inverter is always operating at the maximum power point of the PV module, thereby effectively improving the energy yield of the bifacial module.

2.4 Secure and Reliable Protection Design

1. The fuse failure rate increases as the current increases.

   The current of the PV module is affected by radiation and temperature, so it cannot be controlled. When the fuse has a low-current overload, the fusing time becomes long. When the fuse is almost blown, it is in a high-temperature heat balance state, or the insulation between the cable and the fuse box is damaged. As a result, fire accidents may occur. The output current of a bifacial module is even larger, which is more likely to cause low-current overload. The fuse can then be blown or even result in a fire due to such high temperatures.

Figure 2-3 Fuse faults caused by high temperatures

2. The fuse of a single specification cannot adapt to the current mainstream PV modules.

   Currently, the maximum reverse withstand current capabilities of bifacial modules from mainstream vendors are 15 A and 20 A, as listed in the following tables. In this case, the DC combiner box or the string inverter with built-in fuses cannot adapt to the PV modules of another specification regardless of the fuse specifications. That is, the built-in 20 A fuse cannot protect the 15 A PV module and the built-in 15 A fuse is blown frequently due to the large operating current.

Table 2-2 Maximum rated current of fuses from two mainstream bifacial module vendors

Operating Parameters	
Operating temperature	-40°C ~ +85°C
Power tolerance	0 ~ +5 W
Open-circuit voltage and short-circuit current tolerance	±3%
Maximum system voltage	DC1500V (IEC)
Maximum rated current of the fuse	15A
Nominal operating temperature	45±2°C
Security protection level	Class Ⅱ
Bifacial factor	≥75%

Limit Parameters	
Operating temperature	-40°C ~ +85°C
Maximum system voltage	1500V DC (IEC) 1000V DC (UL)
Maximum rated current of the fuse	20A

Note: Do not connect two strings or more PV modules in parallel to the same fuse in the combiner box.

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Every two strings of Huawei upcoming string inverter dedicated for bifacial modules form one MPPT circuit and adopt a fuseless security protection solution. The design ensures that no overcurrent will occur, protects PV modules, and improves system reliability. In addition, security risks, frequent fuse replacement, and energy yield loss caused by fuse faults are avoided.

To sum this up, we compared the Huawei FusionSolar Smart PV Solution with the current mainstream inverter solutions, as described in the following table.

Table 2-3 Comparison of solutions for bifacial module scenarios

Comparison Item of bifacial modules Matching Different Solutions	Traditional Centralized Solution	Traditional String Solution	Smart PV Solution
Increase of the inverter input DC	Good The number of combiner boxes is reduced.	Poor The MPPT input current is not increased.	Excellent The MPPT input current is increased.
Inverter MPPT granularity	Poor Hundreds of strings form one MPPT circuit.	Good Multiple (more than two) strings form one MPPT circuit.	Excellent Two strings form one MPPT circuit.
Inverter fuse fault	Poor	Poor	Excellent Two strings form one MPPT circuit and there is no fuse.
Summary	Not recommended	Available	Best choice for bifacial modules

3 Application Cases of Bifacial Modules and Optimal Inverters and Solutions

Huawei FusionSolar Smart Solution with upcoming string inverter have the following features:

- Higher input current and highest efficiency
- Finer MPPT Granularity
- Highly adaptive, the most accurate and efficient MPPT
- Secure and reliable protection design

These four smart tools make Huawei string inverter and FusionSolar Smart PV Solution the best match for bifacial modules.

In fact, the solutions composed of Huawei inverters and bifacial modules have been widely applied to bifacial module plants in various scenarios in China. The following table lists some cases.

Table 3-1 Cases of Huawei string inverters used in bifacial module plants in China

Location	Capacity	Scenario	Grid-connection Time	PV Module Type	PV Module Power	Mount Type	Inverter	Energy Yield Gain
Gonghe	1 MW	Gobi	June 2016	HIT	360	Fixed mount	SUN2000-50KTL-C1	10.5%
	1.3 MW					Horizontal single axis		

Location	Capacity	Scenario	Grid-connection Time	PV Module Type	PV Module Power	Mount Type	Inverter	Energy Yield Gain
Golmud	20 MW	Yellow sand	August 2017	P-type	350	Horizontal single axis	SUN2000-50KTL-C1	13%
	20 MW			N-type	350			
	10 MW			P-type	350			
	10 MW			P-type	345			
Datong	30 MW	Grassland	June 2017	N-type	310	Fixed mount	SUN2000-50KTL-C1	5%
	30–40 MW			N-type	310			
Xintai	100 MW	Solar-agricultural	December 2017	N-type	310	Horizontal single axis	SUN2000-50KTL-C1	22%
Lianghuai	8–10 MW	Water surface	November 2017	N-type	290	Fixed mount	SUN2000-50KTL-C1	15%

Note: The best match for bifacial modules is the SUN2000-50KTL-C1 in China.

Case 1: Gonghe Bifacial module plant

COD: June 2016

Capacity: 1 MW of fixed mounts and 1.3 MW of horizontal single axis trackers

Inverter: Huawei SUN2000-50KTL-C1

PV module: 360 W HIT bifacial module

Application scenario: grassland and sand

Energy yield gain (compared with standard PV modules): 10.5%

Case 2: Golmud bifacial module plant


COD: gradually connected to the grid since August 2017

Capacity: 60 MW of horizontal single axis trackers

Inverter: Huawei SUN2000-50KTL-C1

PV module: 345 W and 350 W PV modules

Application scenario: desert

Energy yield gain (compared with standard PV modules): 13%

Case 3: Xintai solar-agricultural project

COD: November 2017

Capacity: 100 MW of single axis trackers

Inverter: Huawei SUN2000-50KTL-C1

PV module: 310 W PV module

Application scenario: solar-agricultural scenario

Energy yield gain (compared with standard PV modules): 22%

Case 4: Lianghuai floating PV plant

COD: December 2017

Capacity: 10 MW

Inverter: Huawei SUN2000-50KTL-C1

PV module: 285 W PV module

Application scenario: white floats on the water surface

Energy yield gain (compared with standard PV modules): 15%

4 Summary

The bifacial module has started a new round of technology replacement. The application of new technologies requires the development of other new technologies, such as the higher inverter input current, finer MPPT granularity, more accurate MPPT algorithms, and smarter design tools for bifacial module plants. The Huawei string inverter configured with multi MPPTs is the best match for bifacial modules, and also the main technical solution for lowering levelized cost of energy (LCOE) in the PV Industry. Huawei FusionSolar Smart PV Solution greatly optimizes initial investments, reduces O&M costs, raises energy yield, and increases ROI of the PV plant. It is bound to lead the healthy and sustainable development of the PV industry.