

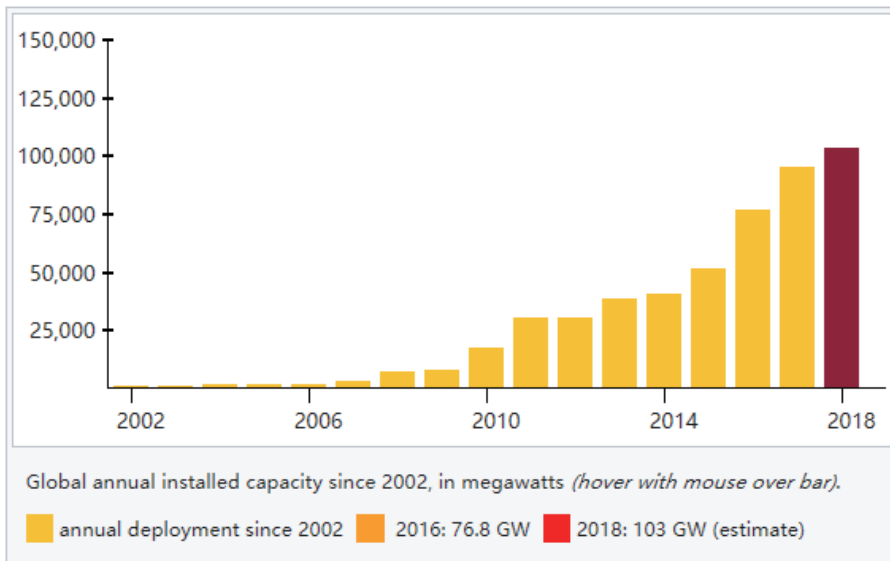
Trend of Bi-facial Modules

VER: 01, UPDATED ON MAY 08TH, 2020

Bi-facial solar module is able to absorb additional sunlight by rear surface, which is a significant advantage compared to traditional mono-facial solar module. With the additional solar radiation accumulated by the rear surface, it will bring more electrical power generation. As the interests in bi-facial module grows, a worldwide map of their potential performance can help assess and accelerate the global deployment of this emerging technology.

1. Market Trend of Bi-facial Module

As the most promising technological breakthrough in PV industry, the annual deployment of bi-facial modules has grown from 97 MW in 2016 to 5.42 GW in 2019, and the cumulative capacity has reached 8.2 GW, which had taken nearly 8 years for mono-facial module since the implementation of Germany’s feed-in tariff program in 2000.



Annual installed capacity in 2008 is 6.67 GW-Figure from “World annual deployment” on Wikipedia (https://en.wikipedia.org/wiki/Growth_of_photovoltaics)

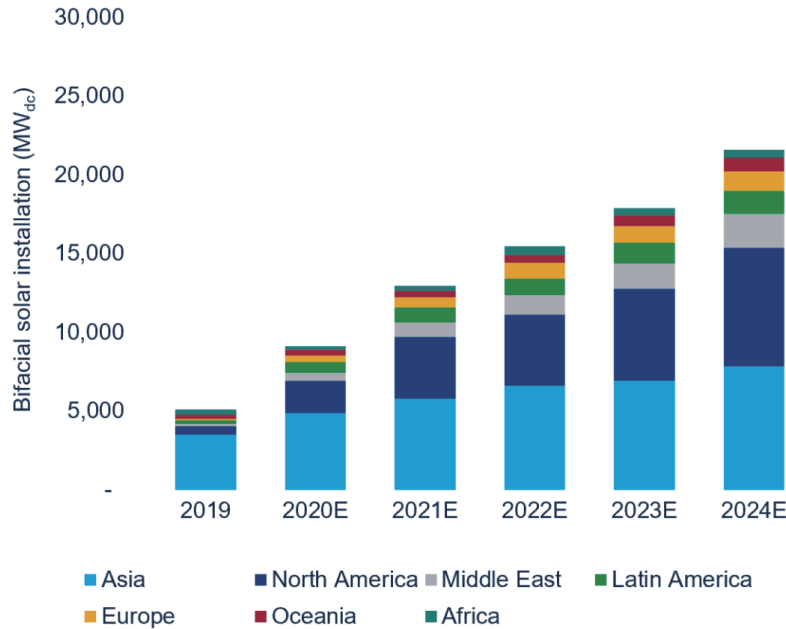
Based on current trend, the annual bi-facial module capacity will exceed 21 GW by 2024, accounting for 17.2 percent of the total installed capacity in that year, quadrupling the share of bi-facial solar in 2019.



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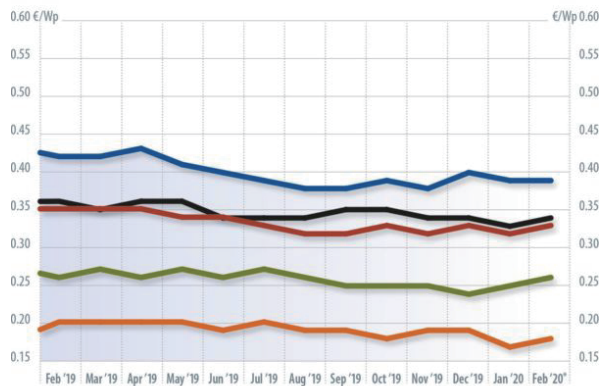
Forecast of global annual installed bifacial solar capacity, 2019 – 2024E (MW_{dc})



Source: Wood Mackenzie Power & Renewables

As the demands grow following the market's prediction, most mainstream manufacturers have joined the team by deploying resources for bi-facial production. Thus, the price of bi-facial module keeps in a downtrend that the price has reduced 9.3% since January 2019, which keeps shortening the price difference with the high efficiency and mainstream modules.

EU spot market module prices by technology



Crystalline modules (mono-/poly-Si) average net prices (€/Wp)

- High efficiency:** Crystalline modules 290 Wp and above with Cello, PERC, HIT-, n-type – or back-contact cells or combinations thereof
- Mainstream:** Modules with usually 60 cells, standard aluminum frames, white backing and 260 Wp to 285 Wp – the majority of modules on the market
- Bifacial:** Modules with bifacial cells, transparent backsheets or glass-glass, framed and unframed
- All black:** Module types with black backsheets, black frames and rated outputs of between 200 Wp and 320 Wp
- Low cost:** Reduced-capacity modules, factory seconds, insolvency goods, used modules (crystalline), products with limited or no guarantee

* Data up to February 17, 2020
More information: www.pvXchange.com

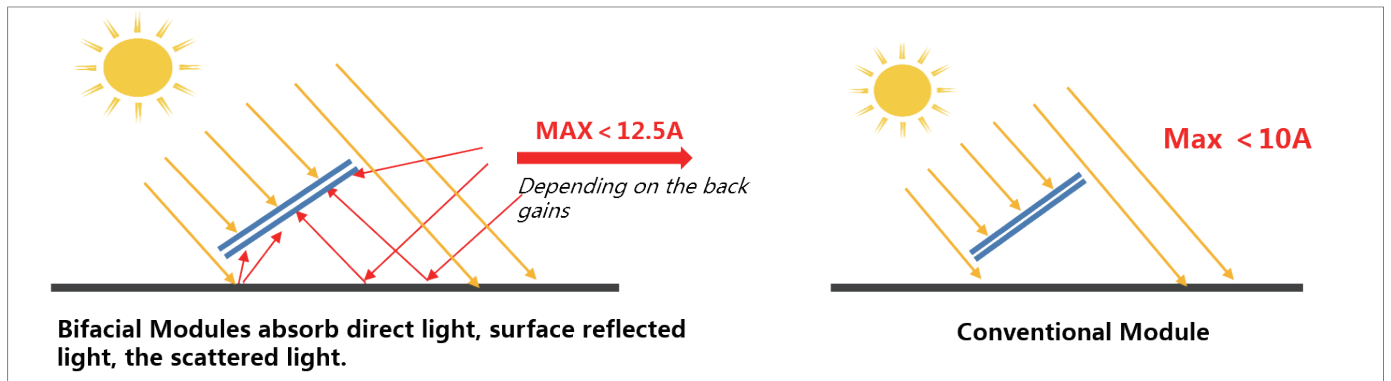
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2. The Working Principle of Bi-facial Module

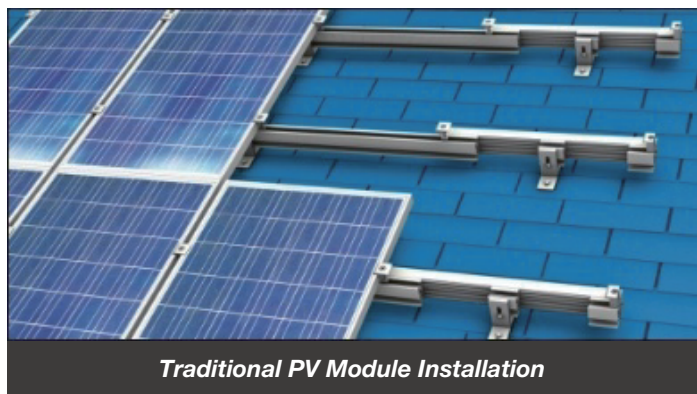
As the name suggests, bi-facial module is consisted of glass sheets on both sides of a solar module. The bi-facial module could absorb both direct and indirect sunlight.



Compared with the standard PV module, the extra yield is the most obvious and realistic advantage of bi-facial module. By installing the bi-facial modules at certain height above the surface with high albedo, the whole system could generate extra power compared with the traditional design.



Also, the installation of the bi-facial module is different from traditional practice. In order to absorb more lights, the frames used will not block the backside of the panel.



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3. Benefit Variation of Bi-facial System

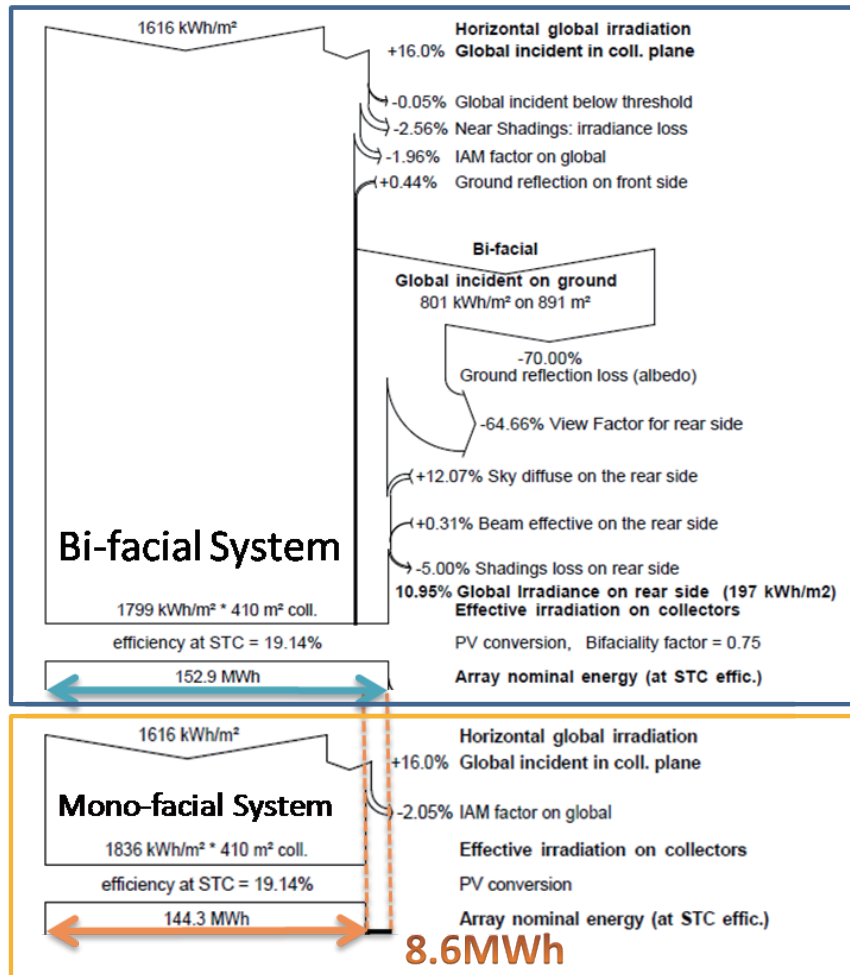
To better understand the extra benefits from bi-facial module, here we use two simulated systems to explore the difference. Here are two PV system simulations in PVSyst - one is with the traditional mono-facial module LR6-71 HIBD 385M plus GW60KN-MT; another is with bi-facial module LR6-72 HBD 385 M Bifacial plus GW60K-BF, which is especially developed for the application of bi-facial modules.

| | Module | Inverter | Module | Inverter |
|-------------------|--------------------------------------|---|------------------------------|-----------------------------------|
| Brand | Longi | GoodWe | Longi | GoodWe |
| Model | LR6-72 HIBD 385 M | GW60KN-MT | LR6-72 HBD 385 M Bifacial | GW60K-BF |
| | Voc: 48.7V | Vmax: 1100V | Voc: 48.9V | Vmax: 1100V |
| | Vmpp: 40.4V | Vmpp: 200-1000V | Vmpp: 40.4V | Vmpp: 200-1000V |
| | Isc: 10.08A | Num of MPPT: 4 | Isc: 10.03A | Num of MPPT: 4 |
| | Imp: 9.53A | String per MPPT: 3/3/3/3 | Imp: 9.53A | String per MPPT: 3/3/3/3 |
| | | Max Input Current: 33/33/33/33 | | Max Input Current: 44/44/44/44 |
| | | Max Short Current: 41.5/41.5/41.5/41.5 | | Max Short Current: 55/55/55/55 |
| Location | Valencia, Spain | | | |
| Position | Latitude 39.48°N, Longitude: -0.38°W | | | |
| Tilt & Azimuth | 30° & 0° | | | |
| Ground Albedo | 30% | | | |
| Number of Modules | In Series: 17 modules | In parallel: 12 strings | In total: 204 pcs | |
| Nominal Power | Nominal(STC): 78.5kWp | Nominal(Inv): 60kWac | Pnom ratio: 1.31 | |
| PR | 86.69% | 127.6MWh/year | 90.94% | 133.9MWh/year |

With the same number of PV modules and inverters deployed, the system capacity is completely same located in the Valencia and the estimated ground albedo is 30%. However, due to the usage of bi-facial modules together with GoodWe's 60KW inverter applicable for bi-facial modules, there is additional 6MWh generation compared with the regular mono-facial modules after the simulation in PVSyst. From the following comparison of Loss Diagram, before considering the power loss of PV and Inverter, there is additional 12.38% power generated from the direct beam and diffuse light absorbed by the rear of the bi-facial modules, which is about 8.6MWh per year.

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Conclusion

As bi-facial modules generate more power than mono-facial modules in PV system, it will become the mainstream choice for most of the utility-scale projects, but the market will need more practical data from the previous installation to prove its potential for the investors.

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