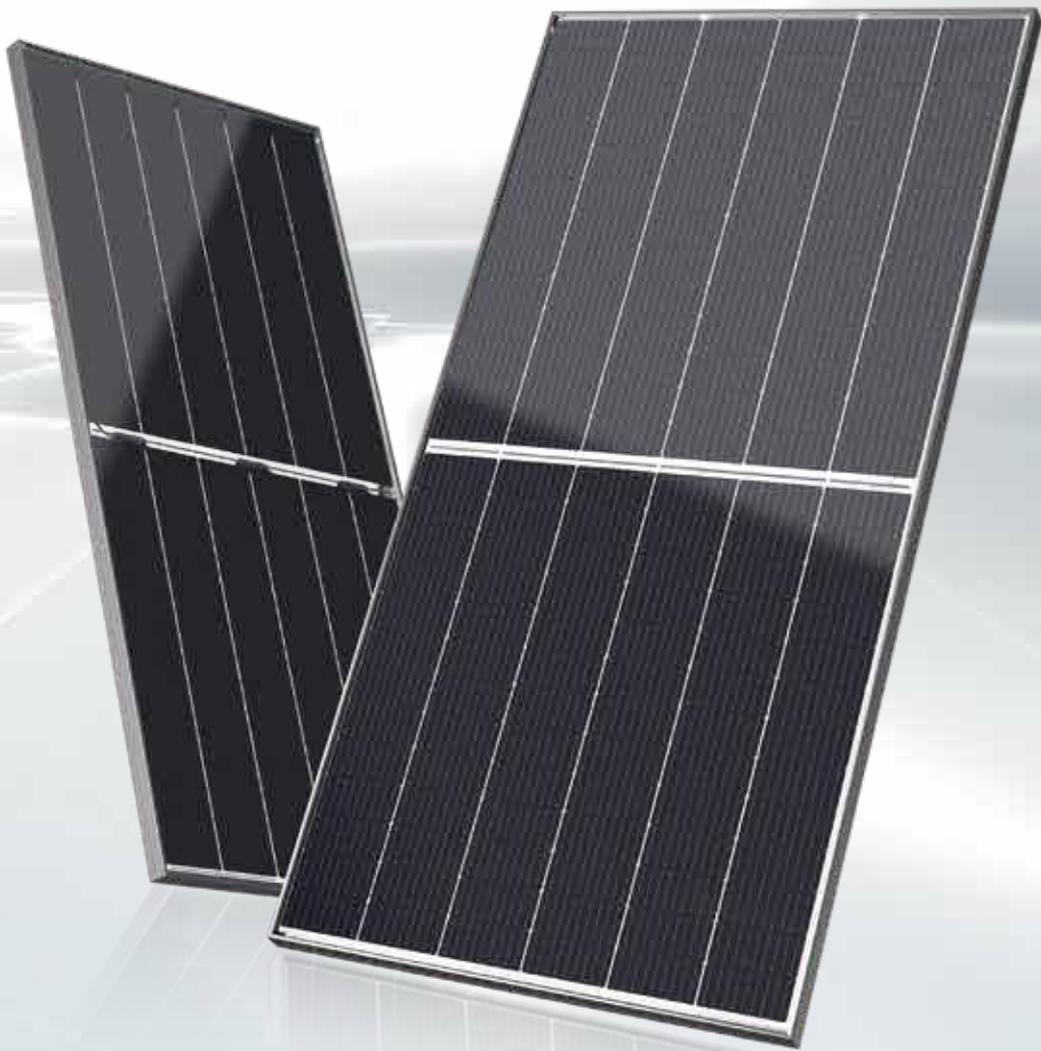
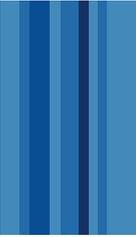


Analysis on the design and application of Tiger Pro system





JinkoSolar's new Tiger Pro series redefines the highest power in the PV industry with 580W, which also emphasizes that JinkoSolar has entered a new era for with their its modules with of 500W. The response for the launch of the Tiger Pro series has been overwhelming. JinkoSolar is turning the attention of the industry to the technology rather than the size of the silicon wafers. Meanwhile, the industry has given positive feedback on the system compatibility and system cost reduction of the Tiger Pro series.

The design and application advantages of the new Tiger Pro products on the system side are as follows:

1. Lower Voc, lower temperature coefficients

The low Voc and temperature coefficients of the modules can increase the number of modules on the unit group string, and if the DC side capacity of the project is known, the total number of strings in the project will be reduced. It is well known that if the total number of modules in the system is reduced, on one hand, the corresponding cable costs and mounting system costs will be reduced, on the other hand, the labor costs involved in the project will be much significantly reduced as well. Especially for large photovoltaic projects, the capacity ratio of the whole project can also be improved accordingly. The Voc under standard conditions for our new Tiger Pro module is 49.5V (double-sided). 530W@STC=25°C G=1000W/m², AM=1.5).

Assuming that the lowest historical temperature ever recorded of a place is 0 degrees, using 530W modules in a 1500V system on the DC side, the temperature coefficient is -0.28%/ C. According to the standard calculation method recommended by IEC62548, each series of components can take up to 28 strings per group. We also use modules from two other manufacturers for comparison.

Below is a screenshot of the IEC standard:

$$N \leq \frac{V_{DC,MAX}}{V_{OC} (1 + C_{T,V} (T_{Lowest} - 25))} \quad (2.1)$$

Where $C_{T,V}$ temperature coefficient of Voc.

This is the standard algorithm recommended by IEC, where Voc is open-circuit voltage under standard conditions, Vdcmx is system voltage, and Tlowest is minimum historical temperature ever recorded.

	Tiger Pro 530W	Factory 2 500W	Factory 3 500W
Open circuit voltage (V)	49.5	51	51.5
Number of components per group string (based on IEC standards)	28	27	27
Number of components per group string (calculated according to the inverter manufacturer)	29	28	27

IEC standard algorithm vs Inverter manufacturer recommended algorithm (calculated when minimum temperature is set to zero)

If the calculation method recommended by some inverters vendors is used, the operating temperature of the modules will be higher than the ambient temperature due to the consideration of the heat caused by solar irradiance, then the temperature correction value of the module's Voc will be increased, and a single set of strings can connect more modules.

2. Higher efficiency and power levels

More efficient, the area of the entire PV plant area will be reduced, which can bring to a significantly reduce significant reduction the land lease area of the project; higher power levels, for the cost of the stand, will also reduce lower the cost of the allocated single-watt stand, especially at low wind speeds. Of course, module products with efficient and high-power will also bring greater power generation benefits to the project.

Taking a place in Vietnam as a research object, we used Tiger Pro 530W modules and found other types of modules to compare the BOS cost differences of different modules. We can see that the BOS cost of modules varies due to different power levels, and Tiger Pro 530W modules perform better in comparison.

120MW Vietnam Project	Tiger Pro 530W	G12 500W	M6 445W
Configuration information			
First year (MWh)	200,200	200,200	200,200
Number of modules per string	30	29	30
Number of inverters	518	518	518
STotal number of modules	1,500	1,500	1,500
System Voltage (V)	226,416	240,000	266,667
Total Number of Group Strings	7,548	8,276	8,889
BOS Cost			
BOS Cost (%)	0	+1.85%	+2.31%

BOS cost comparison (assuming that the model and cost of the inverters are the same, the first year of the project generates the same amount of electricity)

3. Higher compatibility with tracking mounting system and lower LCOE

Through the communication with many manufacturers, the size and weight of Tiger Pro products are more friendly for the design of tracking mounting system. Generally speaking, the tracking mounting system is composed of columns, spin axis and purlin bars, and the cost of the mounting system is also composed of these parts; and among the mounting system costs, spin axis account for the largest proportion, generally 25-35%. Based on the relationship between the torque load and the length of the modules, it can be considered that the torque load is proportional to the square of the length of the component.

For Tiger Pro 72 tiling ribbon/Transparent Back board Backsheet modules, the length and weight of modules will be smaller than those of other manufacturers in the same industry due to the use of tiling ribbon and Transparent Backsheet technology, resulting in reduced shaft costs. As the most important part of the total cost, this part affects the total cost the most.

In addition, the load area decreases as the length of the modules is reduced decreases, as well as the corresponding wind and snow loads, which indirectly lower reduces the cost of the fixtures for the mounting system.

According to the model provided by the mounting system manufacturer, the cost of single-watt for the mounting system is mainly inversely proportional to the size of power in low-wind pressure areas, so the higher the power of modules, the lower the cost of single-watt for the mounting system; however, in high-wind pressure areas, the cost of single-watt for the mounting system is positively related to the length of modules. Comparing Tiger Pro with modules from other manufacturers at the same power according to the data provided by the tracking mounting system manufacturer, we can see that although the components panels have the same power, the cost per watt of the mounting system is also different due to the different length of the

Module Length (mm)	Number of modules per string	Recommended mounting system placement under moderate high wind pressure	Total power	Cost per watt	Power level
2230	28	2x28(outside) & 2x42 (inside)	44520	0.03911	530
2267	28	2x28(outside) & 2x42 (inside)	44520	0.04038	530

Tracking mounting system cost comparisons between two modules provided by the mounting system manufacturer (moderate and high wind pressures)

4. High compatibility between bifacial modules and inverters

Through a lot of experiments, we know that the short-circuit current and working current of bifacial modules are much higher than those of mono-facial modules. At present, the maximum input current of MPPT of mainstream string inverters is 26A, while when the back gain is more than 30%, and the solar irradiance is very good ($>1000\text{W}/\text{m}^2$), the output current of the modules may be more than 13A. If one MPPT of the inverter connects two groups of strings, the output of the modules will be lost. In order to bring higher power generation and lower power cost to clients, we have been in close communication with several mainstream inverter manufacturers to promote the launch of high current inverter products in response to JinkoSolar's bifacial modules with high performance. We take a place in Vietnam as the research object, import the data into PVsyst for simulation, and get the following results:

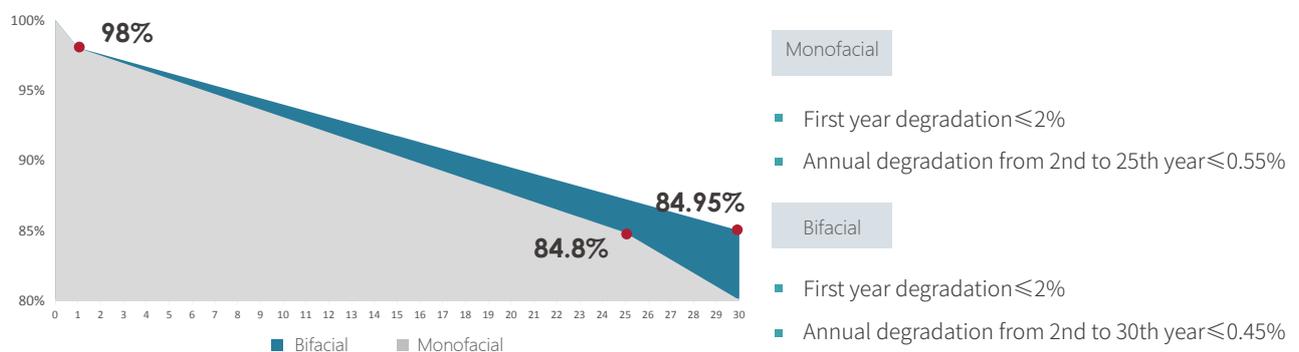
	26A Maximum Input Current Inverter	30A Maximum Input Current Inverter
Component Model	Tiger Pro Two-sided 530w	Tiger Pro Two-sided 530w
Number of components	16200	16200
Number of inverters	32	32
Hours of Annual Power Generation	1650	1694

Simulation results of Power generation using different inverters for a project in Vietnam

we can see that the inverters with high input current will be better optimized on the power generation of Tiger Pro products to a higher level.

5. Higher production processes and product quality

JinkoSolar's modules have been rated as the most financing photovoltaic modules products in the industry, which is precisely because of its excellent production process and high standard production process. As a new product, Tiger Pro has higher product quality. In today's 1500V system era, high-quality modules products have lower mismatch rate between groups and modules in long strings, which makes it easier for inverters to track to the maximum power point, especially in power stations that have been running for many years.



In summary, JinkoSolar's Tiger Pro has advantages in both cost reduction and compatibility on the system side, and this series of products may become one of the mainstream module selections in the new industry.

How Does Tiger Pro of JinkoSolar Achieve a Lower LCOE from the Aspect of PV System?

Along with the subsidy-free grid parity policy's release of National Development and Reform Commission and National Energy Administration, PV module power is upgrading unrelentingly to meet the demand of the era of subsidy-free grid parity. With the rapid technology innovation, the diversity of technology type and power class of PV module increases gradually among manufacturers over time. On May 15th, 2020, Jinko Solar launches its latest PV module with 580W maximum power and 21.6% efficiency. It indicates, to some extent, a rise of competition in production capacity and performance of PV module. Most mainstream manufacturers launch their high-efficient modules one after another. Under this circumstance, more and more investors and EPCs pay great attention to high-efficient modules especially after the release of Jinko Solar's latest product. Therefore, the topic about how high-efficient modules achieve a lower LCOE in PV system will spark a heated discussion on a wide-range power escalation.

From the perspective of third party, TÜV NORD makes a series of analysis and comparison between high-efficient PV module of Jinko Solar and other two mainstream products. In the report, on the assumed condition of 120MW DC-side project, economic performance of Jinko Solar's 530W/535W PV module is compared with others from the aspects of technical proposal review and financial income analysis. Regardless of the first-year power generation gain, final revenue will be evaluated to meet the demand of investors and EPCs.

In order to fairly and objectively compare the performance of the three modules applied to the project, TÜV NORD selected and analyzed the same project site as comparison condition. The purpose is to limit the uncertain factors of evaluation results under the conditions of the same geographical location, type of power plant, meteorological conditions, on-grid electricity price, and tax policy. For the convenience of comparison, Golmud in Qinghai is chosen as the project site. The annual irradiation of this area reaches up to 2195 hours, which belongs to the first-class light area in China. The annual temperature is low, average 6.69 degrees centigrade annually. And the ground of PV area is relatively flat.

Project Site	Golmud, Qinghai
Project Capacity	120MW
GPS	94.55°E 36.26°N
Annual Irradiation Hour	2195
Altitude	2800 meters
Annual Average Temperature	6.69°C

The basic information of the site is as follows

Combined with TÜV NORD's analogy analysis of existing projects on the market, the initial investment costs of the three module solutions can be estimated and deduced, including the costs of pre-project development, EPC and grid connection. Then, by inputting Jinko 530/535W module's pan-file into the PV Syst software, the first year's power generation can be calculated through simulation. At the same time, in order to eliminate the loss of the abandoned light rate and achieve a uniform power generation, we uniformly set the DC/AC ratio as 1.1. In addition, it is also assumed that the 3 cases have the same degradation and OM cost. In conclusion, the results are as follows:

	Case 1	Case 2	Case 3
Module Model	Jinko-530/535	XX-500	XX-450
Module Power (W)	530/535	500	450
Module Efficiency	21.4%/21.6%	20.90%	20.70%
First Year Generation (MWh)	264,114	264,114	264,114
Modules Number per String	26	25	26
Inverters Number	35	35	35
DC/AC Ratio	1.10	1.10	1.10
Inverter Power (kWac)	3,125	3,125	3,125
Modules Number	227,006	240,625	267,362
Strings Number	8,731	9,625	10,284
EPC per Watt	4.0073	4.0710	4.1208
First Year OM Cost (yuan/kW/year)	60.70	60.70	60.70
Total Investment (yuan)	496,560,340	504,224,143	510,217,017
Equity Capital (yuan)	148,968,102	151,267,243	153,065,105
LCOE (yuan/kWh)	0.2989	0.3028	0.3058
Equity Capital IRR	15.85%	15.39%	15.04%

Under the established unified DC capacity, land availability and module price, the case 1 of Jinko 530/535W module has great advantages over case 2 and 3, such as LCOE and IRR, which mainly reflects in the following aspects:

1 / Use of MBB and TR Technologies

Tilling Ribbon, multi-bus bar technology leads to a higher power and higher efficiency. For the all system, higher power module can reduce the number of strings in the condition of same DC/AC ratio. Likewise, the cost of corresponding DC cables, PV mounts, combiner boxes and their installation, even the land of PV will be cut down accordingly. The more efficient module with tracker designed will increase the power generation and reduce the mounting system area. So the cost per watt is decreased, especially for the commonly used 2P tracker.

2 / Lower Module Open-Circuit Voltage (Voc)

In the design, the lower open circuit voltage can increase module numbers per string, which will reduce the number of strings in the system, as well as the corresponding tracker, cables, and installation costs. Thereby the total cost of the project can be cut down.

3 / High Module Quality and Reliability

Jinko Solar is known for its high-level production lines in the industry. The failure rate and dispersion rate of production lines are relatively low, resulting in the low mismatch rate in of 1500V DC part. High-quality and high-reliable module can greatly improve the inverter MPPT tracking efficiency and result, achieving higher inverter' s output.

Auditing from the results of this evaluation, Jinko 530/535W module has certain market competitive advantages technically and economically.

