Swan Bifacial Module

JinkoSolar Co., Ltd.
Short Introduction of JKS

- Shipment #1
- Delivered 40GW
- Market Share 12.8%
- Cell Efficiency Record 24.58%
- Bankability #1

6 Global Factories | 34 Sales Offices | 80+ countries where Modules are delivered | 13,000+ Employees

Data source: By the end of 2018
### JKS Product Portfolio 2019

<table>
<thead>
<tr>
<th>Model</th>
<th>Power (Wp)</th>
<th>Efficiency</th>
<th>Warranty</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cheetah FC</strong></td>
<td>400Wp</td>
<td>20.17%</td>
<td>25 Year Linear Power Warranty</td>
<td></td>
</tr>
<tr>
<td><strong>Cheetah HC</strong></td>
<td>410Wp</td>
<td>20.38%</td>
<td>25 Year Linear Power Warranty</td>
<td></td>
</tr>
<tr>
<td><strong>Swan Bifacial DG</strong></td>
<td>400Wp (front only)</td>
<td>19.54%</td>
<td>30 Year Linear Power Warranty</td>
<td>Lower weight</td>
</tr>
<tr>
<td><strong>Swan Bifacial TB</strong></td>
<td>400Wp (front only)</td>
<td>19.54%</td>
<td>30 Year Linear Power Warranty</td>
<td></td>
</tr>
<tr>
<td><strong>Tiger Monofacial</strong></td>
<td>460Wp</td>
<td>20.78%</td>
<td>25 Year Linear Power Warranty</td>
<td></td>
</tr>
<tr>
<td><strong>Tiger Bifacial TB</strong></td>
<td>455Wp (front only)</td>
<td>20.06%</td>
<td>30 Year Linear Power Warranty</td>
<td></td>
</tr>
</tbody>
</table>
JKS Swan Bifacial Features

158.75 mm cell dimension

Bifacial Energy Yield
500+ Total Watt

Front side max power 415 Wp

Rear side: plus 5-25% Power Gain

Cheetah Cell up to 22.3% efficiency

30 Years Linear Power Warranty

Reduces BOS Cost by 3%
Reduces O&M Cost by 5%
30 Years Linear Power Warranty

LINEAR PERFORMANCE WARRANTY

12 Year Product Warranty • 30 Year Linear Power Warranty
0.55% Annual Degradation Over 30 years

- Linear performance warranty
- Standard performance warranty
- P Type Bifacial linear performance warranty

Performance Warranty

✓ 30 years linear power warranty
✓ 2.5% for 1st year and 0.55% from year 2nd to 30th
Bifacial: Test Standard - BSTC

1. STC measurement *
   \[ G_{\text{front}} = 1000 \text{ W/m}^2 \quad \text{and} \quad G_{\text{rear}} = 1000 \text{ W/m}^2 \]
   *The non-illuminated side was covered with non-reflective background and aperture.

2. Determine bifaciality at STC
   \[ \phi_{\text{ISC}} = \frac{I_{\text{ISC}}}{I_{\text{ISCfront}}} \quad \phi_{\text{VOC}} = \frac{V_{\text{VOC}}}{V_{\text{VOCfront}}} \quad \phi_{\text{Pmax}} = \frac{P_{\text{Pmax}}}{P_{\text{Pmaxfront}}} \quad \phi = \min(\phi_{\text{ISC}}, \phi_{\text{Pmax}}) \]

Reference standard: BSTC

Front side: \( G = 1 \text{ kW/m}^2 \)
Rear side: \( G = 1 \text{ kW/m}^2 \)

- Front irradiance: 1000 W/m\(^2\)
- Rear irradiance: 135 W/m\(^2\)
- Equivalent irradiance: \(1000 + \phi \cdot 135\) W/m\(^2\)
- Module temperature: 25\(^\circ\) C
- Angle of Incidence: 0\(^\circ\)
- Spectral irradiance: AM1.5G

BSTC: Considering module with 1m height and 135W/m\(^2\) irradiance of backside

![Diagram of bifacial module with solar angles and ground clearance]
Introduction to Double-sided Components

Power generation gain up to 25%

**Front**
- JKS Bifacial Cell

**Rear**
- Conventional Cell
- JKS Bifacial Cell

Bifacial: double-side power generation

Single-side power generation
White Mesh Backsheet

Transparent mesh backsheet enhances front-side power generation: 5 Wp improvement.

Notes: transparent mesh backsheet has one more mesh layer with high reflectivity and UV-resistance.
Installation Design: Angle & Height

Install tilt Angle:

1. Latitude : 30°(N)~30°(S)  
   \[ \theta = 30° \]
2. Latitude: >30°(N or S)  
   \[ \theta = \text{latitude} \]

Mounting Height:

1.2 m is recommended for fixed racks and 1.5m for trackers
- <1.2 m: Decreasing rear side energy generation gain
- >1.2 m: Increasing mounting construction cost
Installation Design: Ground Coverage Ratio

Energy Generation (kWh/kWp/year)

Bifacial gain

GCR

<table>
<thead>
<tr>
<th>GCR</th>
<th>Bifacial gain</th>
<th>Bifacial</th>
<th>Cheetah</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>54%</td>
<td>850</td>
<td>800</td>
</tr>
<tr>
<td>800</td>
<td>43%</td>
<td>900</td>
<td>850</td>
</tr>
<tr>
<td>850</td>
<td>35%</td>
<td>950</td>
<td>900</td>
</tr>
<tr>
<td>900</td>
<td>30%</td>
<td>1000</td>
<td>950</td>
</tr>
<tr>
<td>950</td>
<td>26%</td>
<td>1050</td>
<td>1000</td>
</tr>
<tr>
<td>1000</td>
<td>10,30%</td>
<td>1100</td>
<td>1050</td>
</tr>
<tr>
<td>1050</td>
<td>10,24%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1100</td>
<td>11,00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bifacial Cheetah Bifacial gain
Installation Design: Shading and Frame

The temperature of shading area on bifacial module with frame is very close to that of frameless module.

Influence of frame shading is negligible.

Average temperature of frame: 50.75°C
Average temperature of frameless: 50.26°C
**Position 2:** transparent bifacial with junction box temperature is higher than ceramic grid bifacial.

Transparent bifacial: 41.19°C  
Ceramic grid bifacial: 36.74°C

**Position 1:** Ceramic grid bifacial temperature of shading cell are consistent with transparent bifacial.

Transparent bifacial: 50.75°C  
Ceramic grid bifacial: 50.26°C

Source: Jinko R&D
Installation Design: Shading and Temperature

- High albedo ground surface condition
- 50mm wide black backsheet with a distance of 50mm to the module
Installation Design: Mismatch loss of bifacial modules

- With installation height > 1 m → Spatial nonuniformity < 5%
Installation Design: DC/AC ratio and inverter

Bifacial DC/AC ratio

\[
\text{DC/AC ratio}_{\text{bifacial}} = \frac{\text{DC/AC ratio}_{\text{monofacial}}}{1 + \text{energy gain}}
\]

<table>
<thead>
<tr>
<th>Albedo</th>
<th>0.25</th>
<th>0.52</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC/AC ratio</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>Clipping loss</td>
<td>0</td>
<td>0.06%</td>
</tr>
<tr>
<td>Bifacial gain</td>
<td>10.46%</td>
<td>10.46%</td>
</tr>
</tbody>
</table>

Clipping loss of different bifacial DC/AC ratio (Location: Shandong China, Project size: 105MW)
O&M: Soiling and Cleaning

Soiling rate of the rear side is only 11.3% of the front side
(Field test result in Chile)

The frequency of bifacial rear-side cleaning is much lower than the front side.

The hydrophobic surface offers excellent anti-staining features, making cleaning of the modules easier.
Real Energy Generation Gain

The electric characteristics: same as bifacial modules with dual glass

Energy generation gain: Consistent with bifacial modules with dual glass
CAS Test Center confirmed that bifacial Module gained **18%** in white-painted ground, keeping same with JINKO internal test result.

<table>
<thead>
<tr>
<th>Ground</th>
<th>Water</th>
<th>Grass</th>
<th>Cement</th>
<th>Sand</th>
<th>White-paint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albedo</td>
<td>~3%</td>
<td>~15%</td>
<td>~32%</td>
<td>~24%</td>
<td>~80%</td>
</tr>
<tr>
<td>Actual Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JINKO</td>
<td>4-5%</td>
<td>6-7%</td>
<td>6-7%</td>
<td>7-9%</td>
<td>17-19%</td>
</tr>
<tr>
<td>Third-Party(CAS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>System PR</td>
<td>Baseline=80%</td>
<td>83-84%</td>
<td>84-86%</td>
<td>84-86%</td>
<td>85-90%</td>
</tr>
</tbody>
</table>

**Notes:** Chinese Academy of Sciences (CAS) is the highest academic institution of natural sciences, the highest scientific and technological advisory body, and the comprehensive research and development center of natural sciences and high technology in China.
Installation Design: Fixed tilt or Tracking

Energy Gain (%)
Simulated, albedo 0.35
Location: Haining, China

Benchmark
Case Study 1: White paint Fixed installation

Swan bifacial reached average 16% bifacial gain compared with monofacial modules, and in summer energy gain was up to 20%.
Case Study 2: Grass Fixed Mounting System

Location: Lv Liang, ShanXi Province
Tilt Angle: 30°
Installation Height: 0.3m-1.2m above from the ground
Ground Type: Grass/Soil
Testing Date: 2019.1~2019.6

- Gain of bifacial modules is 9.05% compared with monofacial modules
- Bifacial modules gain is proportionally higher in low-irradiance environments
- Energy gain reached 15.07% in January with many overcast days
Thank you!

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