Ultra-high performance panels in the utility scale projects in the European markets

24.04.2019
Andrea Viaro, Head of Technical Service Jinko Solar Europe
Facts and Figures

6 Global Factories
34 Sales Offices
80+ Countries where the modules are delivered
12,000 Employees

11.3 GW Capacity (‘18)
40 GW Delivered (Dec’18)
JinkoSolar’s Major Milestones

- 2006: World First’s solar company established
- World First’s solar company passing 85-85 PID test
- 2010: JinkoSolar’s major milestones
- TÜV NORD strategic collaboration agreement
- 2012: First in China
- 2013: “Top Performer” in all tests
- 2015: Launch of Factory 4.0
- 2017: 4 times
- 2018: “Top Performer” in all tests
- 2019: Launch of Factory 4.0

- Listed on NYSE
- Ranked No.2 in Photon Laboratory
- The Most Bankable Brand in IPP Projects
- Bloomberg New Energy Finance HC mass production
- 10% global market share
- World Record mono-PERC cell efficiency 23.95%
JINKO as the Most Bankable Brand in IPP Projects

**Top 10 Solar Module Suppliers of 2018**

<table>
<thead>
<tr>
<th>#</th>
<th>Module Supplier</th>
<th>Y/Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JinkoSolar</td>
<td>⇐</td>
</tr>
<tr>
<td>2</td>
<td>JA Solar</td>
<td>↑</td>
</tr>
<tr>
<td>3</td>
<td>Trina Solar</td>
<td>↓</td>
</tr>
<tr>
<td>4</td>
<td>LONGi Solar</td>
<td>↑</td>
</tr>
<tr>
<td>5</td>
<td>Canadian Solar</td>
<td>⇐</td>
</tr>
<tr>
<td>6</td>
<td>Hanwha Q-CELLS</td>
<td>⇐</td>
</tr>
<tr>
<td>7</td>
<td>Risen Energy</td>
<td>↑</td>
</tr>
<tr>
<td>8</td>
<td>GCL-SI</td>
<td>⇐</td>
</tr>
<tr>
<td>9</td>
<td>Talesun</td>
<td>↑</td>
</tr>
<tr>
<td>10</td>
<td>First Solar</td>
<td>↑</td>
</tr>
</tbody>
</table>

**Figure 3: Top 20 PV module brands used in term-loan financed projects after July 1, 2016**

<table>
<thead>
<tr>
<th>Brand</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jinko Solar</td>
<td>1,796</td>
</tr>
<tr>
<td>First Solar</td>
<td>1,417</td>
</tr>
<tr>
<td>Longi</td>
<td>1,025</td>
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<tr>
<td>ZNShine</td>
<td>774</td>
</tr>
<tr>
<td>JA Solar</td>
<td>766</td>
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<tr>
<td>REC Group</td>
<td>533</td>
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<tr>
<td>Suntech</td>
<td>509</td>
</tr>
<tr>
<td>Risen</td>
<td>477</td>
</tr>
<tr>
<td>Trina Solar</td>
<td>430</td>
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<tr>
<td>Talesun</td>
<td>339</td>
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<tr>
<td>Hareon Solar</td>
<td>311</td>
</tr>
<tr>
<td>HT-SAAE</td>
<td>302</td>
</tr>
<tr>
<td>Lightway Solar</td>
<td>233</td>
</tr>
<tr>
<td>BYD</td>
<td>225</td>
</tr>
<tr>
<td>Canadian Solar</td>
<td>207</td>
</tr>
<tr>
<td>Hanwha Q CELLS</td>
<td>184</td>
</tr>
</tbody>
</table>

Source: Bloomberg NEF
R&D Leadership & First Class Components

- **$53M** in 2018 R&D expenditures
- **>400** full-time technical staff
- Dedicated **wafer, cell and module** R&D facilities
- Cooperation with global Research Institutes
- **464 patents** filed
The Quality Pyramid – Built from Solid Foundation

Power

Reliability

Durability
### Third-Party Testing: Accelerated Aging – DNV GL

<table>
<thead>
<tr>
<th>TOP PERFORMER</th>
<th>2018</th>
<th>2017</th>
<th>2016</th>
<th>2014</th>
</tr>
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<tbody>
<tr>
<td>Jinko Solar</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trina Solar</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Yingli Solar</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Astronergy Solar</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hanwha Q CELLS Co., Ltd</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>JA Solar Holdings</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>REC Solar</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>BYD Co, Ltd</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Flex Ltd</td>
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<tr>
<td>GCL System Integration Technology Co., Ltd.</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>LONGi Solar Technology Co, Ltd</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- 4 times “DNV-GL Top Performer” in all tests
- All Module Series tested: Eagle Poly, Mono Standard and PERC HC and Cheetah Series testing ongoing

**TOP PERFORMER in 2018 Test Protocol**
- Damp Heat 1000
- Thermal Cycling 600
- Humidity Freeze 30
- UV Light 90
- Dynamic Mechanical Load 1000
- PID Resistance 192
Levelized Cost Of Electricity

- Module Cost
- Energy Yield
- BOS Cost
- O&M Costs
- Module Efficiency
- System Performance
- Power Density
- IRR
- LCOE
Ultra High Performance Module: Cheetah Series
The New JinkoSolar Cheetah Module

Cheetah
Mono PERC Module Efficiency

Industry leading Large Cell technology (158.75mm x 158.75mm)

Avg. 7Wp power up compared to Cheetah full-cell

Avg. 8Wp power up compared to 156.75mm Mono PERC

Lower BOS costs

Lower thermal losses
Cheetah PERC Mono 72-cell

Power Roadmap (Wp)

Notes: Basic means with Standard Materials; W.E means White EVA
Comparison: BOS Costs

Example: Spain, Sevilla - 42.5 MW Project - ground-mounted fixed racks - 1500V System
Comparison: Lifetime Energy Yield (GWh)

<table>
<thead>
<tr>
<th></th>
<th>350</th>
<th>355</th>
<th>390</th>
<th>390</th>
<th>335</th>
<th>340</th>
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<td>MONO HC</td>
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<tr>
<td>CHEETAH</td>
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<td></td>
<td></td>
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<tr>
<td>CHEETAH HC</td>
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<tr>
<td>POLY</td>
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<tr>
<td>POLY HC</td>
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</tr>
</tbody>
</table>

Example: Spain, Sevilla - 42.5 MW Project - ground-mounted fixed racks - 1500V System
Comparison: Levelized Cost of Electricity (€c/kWh)

Example: Spain, Sevilla - 42.5 MW Project - ground-mounted fixed racks - 1500V System
• Think in terms of EUR/kWh, LCOE, IRR rather than EUR/Wp: **reliability & durability are key**

• Increased module peak power up to **400Wp** maximizes the economic returns and enables lower BOS and labor costs.

• Extended testing such as **PQP (DNV.GL Product Qualification Programme)** better simulate the real-aging conditions in the field **beyond IEC certifications**

• Competitive advantage of **field-proven materials and panel construction**, especially in harsh climatic and temperature-sensitive environments

• **Technical Bankability, Financial Stability**, proven field track record, are key for secure IRR
Thank You!

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PV TECH/ JINKOSOLAR WEBINAR
Rubén Ron. Head of Solar Section

24 April 2019
GLOBAL REACH - LOCAL COMPETENCE

150+ years
100+ countries
100,000+ customers
12,500 employees
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MARITIME

OIL & GAS

ENERGY

BUSINESS ASSURANCE

DIGITAL SOLUTIONS

TECHNOLOGY & RESEARCH
BROAD AND DEEP EXPERTISE IN SOLAR PROJECTS

FEASIBILITY
- Feasibility studies
- Utility grid integration
- Environmental permitting
- Component technology reviews
- Component qualification testing
- Type and component certification of PV inverters

ENGINEERING & DEVELOPMENT
- Due diligence / Independent engineering
- Owner’s engineering
- Energy assessment
- Pre-construction engineering
- Interconnection support
- Project certification

CONSTRUCTION & COMMISSIONING
- Due diligence/ Independent engineering
- Owner’s engineering
- Construction oversight
- System testing and inspection
- Project certification and grid code compliance
- Declaration of conformity
- Module batch testing
- Project certification

OPERATION
- Performance validation
- Resource and energy forecasting
- Existing asset consulting, inspections and decommissioning
- Refinancing and mergers and acquisitions advisory services
- Forensic investigations
- Monitoring, control and asset management
- Project certification

*Our testing, certification and advisory services are independent from each other
10GW

GPM, a DNV GL company, manages 10GW of solar PV plants, which includes 15 mega-plants of over 100MW each

2016

DNV GL acquires GreenPowerMonitor (GPM), a global solar monitoring company, founded in 2006 in Barcelona, Spain

4500+

More than 4,500 financiers, developers and power producers rely on DNV GL’s annual PV Module Reliability Scorecard to inform buying decisions

6000+

We have supported over 6,000 solar projects worldwide from residential to utility scale

2014

DNV GL acquires solar panel testing expert PVEL, based in California, US

*Our testing, certification and advisory services are independent from each other
LATEST TRENDS ON PV MODULE TECHNOLOGY

Tricky Decision for Developers – Investors – Lenders – EPCs

Cell / Module Technology

- Half-cut cells
- PERC
- Bifacial
- IBC
- HJT
- Thin Film

Supporting Structure

- Ground Fix Structure
- One Axis Solar Tracker
Main Challenges – PERC / Bifacial

**Manufacturing**
- Additional steps
- New Materials
- Quality Assurance System

**Technical**
- LID / LeTID
- Long term degradation
- Weight
- Mismatching

**Design**
- Site Selection
- Measurements
- Supporting Structure
- Lower GCR
- Backside shading
- Overtightening bolts. Frameless

**Testing**
- Not fully developed
- IEC 60904-1-2
- Warranties

**Modelling**
- Lack of validation
- Bifaciality factor
- Albedos Variability
- Tracking System

**O&M**
- Limited field experience
- Higher OPEX
- Spare parts in the future
Main Mitigation Measures / Initiatives

- Mixing technologies Mono/bi
- Reducing leverage of debt
- Increased warranty levels
- Manufacturer Bankability reports
- Collaboration with manufacturers
- The importance of BOM
- Maintenance Reserve Account
- Presentations to Banks

U.S. Department of Energy awards study of bifacial PV technology, which could prove a 10% increase in energy output

Research study by DNV GL will be the most comprehensive energy yield analysis for bifacial PV modules to date
### Solar Equipment Classification

<table>
<thead>
<tr>
<th>Categories</th>
<th>Requirements</th>
<th>Level of review</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proven</strong></td>
<td>• &gt; 5 years/&gt; 1 GW</td>
<td>✓ Bankability review</td>
</tr>
<tr>
<td></td>
<td>• 2-5 years, &lt; 1 GW – Add. information required</td>
<td>✓ Full IE review</td>
</tr>
<tr>
<td><strong>Qualified</strong></td>
<td>• Met all required certifications</td>
<td>✓ Fatal flow review</td>
</tr>
<tr>
<td></td>
<td>• 3rd party bankability and reliability test data</td>
<td></td>
</tr>
<tr>
<td><strong>New Technology</strong></td>
<td>• Not Proven nor Qualified</td>
<td></td>
</tr>
</tbody>
</table>
PV MODULE PROCUREMENT BEST PRACTICES

Guidelines are based on:

- Quality/reliability practices commonly observed across industries
- Technology risks which are specific to PV modules
- DNV GL’s extensive experience on advisory

Not every project requires a similar level of quality

- Project size
- Buyers risk aversion
- Manufacturer guarantee level
Thank you

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