N-type in the mainstream – the future of high-efficiency PV technologies and applications

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Acting editor in chief
Solar Media

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JA SOLAR TECHNOLOGY

PV Tech Webinar

JA Solar Technology Co.Ltd.
Q4 / 2023
About JA Solar
May, 2005
Founded in

NASDAQ
Listed on Feb, 2007

Shenzhen Stock Exchange
Listed on Nov, 2019

32591
Employees

US$ 10.6 B
Revenue in 2022

+152 GW
Cumulative Shipments

135
Covered Countries and Regions

13
Global factories

16%
Market Share Global
(2022, S&P Global)

Fortune China 500
Many Consecutive Years Listed on

Top3
In modules shipping
(2022, PV InfoLink)
Branches Worldwide

Location of Sales Subsidiaries
- Germany
- Spain
- Portugal
- Turkey
- The United Arab Emirates
- Netherland
- South Korea
- Japan
- Shanghai
- South Africa
- Australia
- Hong Kong
- Brazil
- America
- Mexico
- Panama
- Colombia
- Chile
- Brazil

Location of Warehouses
- Shanghai
- Hong Kong
- Germany
- South Africa
- Australia
- Japan
- South Korea
- Brazil
- America
- Mexico
- Panama
- Colombia
- Chile
- Brazil

Share of shipments in different regions in 2022:
- China 42%
- Europe 30%
- Middle East & Africa 5%
- America 12%
- Asia-Pacific 11%
- Asia-Pacific 17%
- Middle East & Africa 5%
- Europe 20%
- China 41%

Source: JA Solar

2022 Global Installations by Region:
- China 41%
- America 17%
- Europe 20%
- Asia-Pacific 17%
- Middle East & Africa 5%

Source: S&P Global

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Verticalization and Production Capacity

Deep empowerment of vertical integration, capacity planning of 95GW

Control of the entire production chain

- Ingots 85GW
- Wafers 85GW
- Cells 85GW
- Modules 95GW
- Power Plants

2023 Planned Capacity

Xingtai 10 GW
Hefei 18 GW
Yangzhou 12 GW
Dongtai 10 GW
Fengxian 15 GW
Yiwu 13 GW
Quijing 5 GW
Vietnam 5 GW
United States 2 GW

Note: As of the end of 2023
This report is an annual report covering the period from January 1, 2022, to December 31, 2022.

JA Solar has a zero-tolerance position towards modern slavery and human trafficking and is a signatory to the UN Global Compact Act.

JA Solar undergoes regular third-party audits to ensure compliance with international standards and transparency. (Achilles, Sedex, Ecovadis, CEA, STS)
Comprehensive traceability system

Complete Integrated Traceability System

Total JA Group level ERP/MES system in place alongside physical labelling and indicators
Exact production sites and supplier can be traced completely from serial number
All products are supplied to the downstream production base of JA Group.
Full information on all parts of BOM (glass/frame etc) provenance available on request

- **Suppliers Import**: Detail of suppliers, including import, on-site audit, sample testing, and cross procedure management.
- **Sample Testing**: Certification and reliability, sample validation in production.
- **Validation in production**: Cross procedure management, list of suppliers/approved materials.

- 8 rigorous processes are conducted before introducing a new material
  - JA Solar implements BOM standardization work
  - Bill of high quality qualified materials is called BOM Standard
  - BOM Standard reduces product delivery time
RETC & PVEL Certification

Top Brand PV
EUPD Research

Environmental Product Declaration (EPD)

https://scorecard.pvel.com/manufacturer_name/jasolar/

https://retc.ca.com/pvmi-high-achiever
Quality pyramid

4 AAA
8 RETC
35 PVEL
39 TIER 1
+200 FABRICANTES DE MÓDULOS
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JA Solar
Harvest the Sunshine
Solar Synergy: A Journey into DeepBlue 4.0 Pro's Design and Performance Analysis

Lida Guo
Product Technology Department
2023/12
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01 PV Technologies and Development Trend

02 New-generation N-type Products by JA

03 Product Value of DeepBlue 4.0 Pro
Part 1

PV Technologies and Development Trend
PERC efficiency in mass production ~ 24%, limited space for further efficiency improvement and cost reduction.

After PERC, the new technology still needs to have mass production characteristics, including high efficiency, low cost, good product yield and so on.

TOPCon is this kind of technology, so it will gradually become the mainstream technology in the market.
Considering the power improvement, product yield, reliability and other factors, small spacing gradually become the mainstream of high-density encapsulation technology.
Development Trend of Module Technologies

A. Module cost (price)
Lower module cost, lower initial cost

B. Module efficiency (power)
High efficiency (power) modules can reduce system BOS

C. Power Generation Performance
Modules with excellent power generation performance can reduce the LCOE.

D. Long-term reliability
High reliability ensures stable power generation throughout the entire life cycle

Optimal LCOE (core) considering 4 aspects above Optimal Solution
Part 2

New-generation N-type Products by JA
DeepBlue 4.0 Pro — Core Product

2020
- DeepBlue 3.0
  - 550W/21.3%
  - 415W/21.3%

2021
- DeepBlue 3.0 Pro
  - 560W/21.7%
  - 420W/21.5%

2022
- DeepBlue 4.0 Pro
  - 575W/22.3%
  - 435W/22.3%

2023
- DeepBlue 4.0 Pro
  - 595W/22.5%
  - 450W/22.5%
  - 610W/22.5%
  - 630W/22.5%
In September 2021, JA Solar, Jinko and LONGi jointly announced the standard size of M10 series modules:
- 54c: 1722mm*1134mm
- 72c: 2278mm*1134mm
- 78c: 2465mm*1134mm
- one of the important product specifications in the industry
- widely used in various application scenarios
- has been tested by the market
- showing considerable customer value.

- Adopting 182mm*199mm rectangular wafers. 2465mm*1134mm module size with 72 cells.
- Same dimensions as the original 182-n-78 version, with a power of up to 630W and a module efficiency of 22.5%. The power is the highest among all 182 series products.
- Voc is reduced by 7.6% compared to 78c module. Lower hot spot risk; the number of modules per string is increased; lower BOS costs.
### Module type

<table>
<thead>
<tr>
<th>Wafer size (mm)</th>
<th>54c</th>
<th>48c</th>
<th>66c</th>
<th>72c</th>
<th>78c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1722</td>
<td>1762</td>
<td>1762</td>
<td>2382</td>
<td>2278</td>
<td>2333</td>
</tr>
<tr>
<td>182*182</td>
<td>182*186.8</td>
<td>182*210</td>
<td>182*182</td>
<td>182*186.8</td>
<td>182*182</td>
</tr>
<tr>
<td>182*183.75</td>
<td>182*191.6</td>
<td>182*183.75</td>
<td>182*185.3</td>
<td>182*183.75</td>
<td></td>
</tr>
<tr>
<td>182*185.3</td>
<td>182*185.3</td>
<td>182*185.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- The industry's mainstream 54/66/72/78c modules require at least three different sizes of silicon wafers.
- JA Solar released a new generation of rectangular wafer size solution at SNEC 2023, solving the industry's difficulty in unifying wafer sizes.
• 182*199 rectangular wafer + optimized cell design
  ➔ increased module power
  ➔ produce 4 high-efficiency modules + 1 regular module using only 1 wafer type.

• Better production advantages, performance advantages and customer value.

• Achieve win-win situation for the whole industry.
Industry significance of new generation wafer size

Stronger chain and industry inclusiveness

Excellent equipment compatibility
Uniform material specification
Standard module size
Lower integration cost
Better system value
DeepBlue 4.0 Pro — BYCIUM+ Cell Technology

- Front surface SMBB
- Front surface passivation
- Selective emitter
- n-type silicon base
- RSP + passivated contact
- Rear surface SMBB

- FSP ($J_{0\text{ Front}}<10 \text{fA/m}^2$)
- n-type low-oxygen silicon wafer (12ppm)
- Millisecond Class Lifetime
- RSP ($J_{0\text{ Rear}}<2 \text{fA/m}^2$)
- Double-side ARC + Ultra-fine busbars

25.6% Efficiency in Mass Production

728mV Voc
DeepBlue 4.0 Pro — Core Module Technology

182mm*199mm Rectangular wafer

Highly reliable encapsulation materials

SMBB≥16BB
Main stream round ribbon. ≥ 16BB is adopted with consideration of module power and welding reliability.

Module with High Power & Efficiency —— Rectangular wafer + SMBB + High-density encapsulation + Highly reliable encapsulation materials
DeepBlue 4.0 Pro — Excellent Reliability

LeTID

LID (kWh/m²)

PID

TC

DH

SML+DML + TC50+HF10

IEC
DeepBlue 4.0 Pro — Excellent Reliability

Offshore PV Modules
Saltwater Pressure Immersion and Temperature Testing

- This recognizes the module’s ability to withstand repeated exposure to salty atmospheres, immersion in seawater, and temperature changes caused by seawater splashing on modules in sunlight.

Power loss down to 0.322%
DeepBlue 4.0 Pro — Power Generation

**Lower power degradation**
First year power degradation ≤ 1%, annual power degradation rate ≤ 0.4%, 30-year life cycle, and power generation gain of about 1.8%

**Higher bifacial benefits**
The bifaciality rate is about 80%; the power generation gain brought by a 10% bifaciality increase is around 0.8% - 1.2%

**Better temperature coefficient**
The power temperature coefficient of the module is -0.30%/°C; in high temperature environments, the power generation gain is about 1.5% - 2%

**Better low light performance**
When the irradiance is below 600W/m², the power generation gain is about 0.2%
Part 3

Product Value of DeepBlue 4.0 Pro
### Ground-mounted PV power station, location: northwest China

<table>
<thead>
<tr>
<th>Project</th>
<th>182-72n-2278mm</th>
<th>182-n-2382mm</th>
<th>JAM72D42/LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module power (W)</td>
<td>580</td>
<td>610</td>
<td>630</td>
</tr>
<tr>
<td>Mounting</td>
<td>1P tracker, ±45°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter (kW)</td>
<td>320</td>
<td></td>
<td></td>
</tr>
<tr>
<td>String quantity per mounting frame (string)</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module quantity (pcs.)</td>
<td>222796</td>
<td>211456</td>
<td>204672</td>
</tr>
<tr>
<td>BOS costs</td>
<td>baseline</td>
<td>↓2.64%</td>
<td>↓3.11%</td>
</tr>
<tr>
<td>LCOE</td>
<td>baseline</td>
<td>↓1.27%</td>
<td>↓1.47%</td>
</tr>
</tbody>
</table>

### Ground-mounted PV power station, location: northwest China

<table>
<thead>
<tr>
<th>Project</th>
<th>182-72n-2278mm</th>
<th>182-n-2382mm</th>
<th>JAM72D42/LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module power (W)</td>
<td>580</td>
<td>610</td>
<td>630</td>
</tr>
<tr>
<td>2P tracker, ±45°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter (kW)</td>
<td>225</td>
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</tr>
<tr>
<td>String quantity per mounting frame (string)</td>
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<td></td>
</tr>
<tr>
<td>Module quantity (pcs.)</td>
<td>219456</td>
<td>207872</td>
<td>202176</td>
</tr>
<tr>
<td>BOS costs</td>
<td>baseline</td>
<td>↓4.83%</td>
<td>↓6.77%</td>
</tr>
<tr>
<td>LCOE</td>
<td>baseline</td>
<td>↓1.21%</td>
<td>↓1.81%</td>
</tr>
</tbody>
</table>
### C&I rooftop PV power station, location: eastern China

<table>
<thead>
<tr>
<th>Project</th>
<th>182-72n-2278mm</th>
<th>182-n-2382mm</th>
<th>JAM72D42/LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module power (W)</td>
<td>580</td>
<td>610</td>
<td>630</td>
</tr>
<tr>
<td>Mounting</td>
<td>Fixed tilt, 3°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter (kW)</td>
<td></td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>String quantity per mounting frame (string)</td>
<td>28</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>Module quantity (pcs.)</td>
<td>10472</td>
<td>10080</td>
<td>9828</td>
</tr>
<tr>
<td>BOS costs</td>
<td>baseline</td>
<td>↓2.08%</td>
<td>↓2.75%</td>
</tr>
<tr>
<td>LCOE</td>
<td>baseline</td>
<td>↓1.18%</td>
<td>↓1.61%</td>
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</tbody>
</table>

### Residential rooftop PV power station, location: eastern China

<table>
<thead>
<tr>
<th>Project</th>
<th>182-72n-2278mm</th>
<th>182-n-2382mm</th>
<th>JAM72D42/LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module power (W)</td>
<td>580</td>
<td>610</td>
<td>630</td>
</tr>
<tr>
<td>Mounting</td>
<td>Fixed tilt, 30°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter (kW)</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Module quantity (pcs.)</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOS costs</td>
<td>baseline</td>
<td>↓4.91%</td>
<td>↓7.93%</td>
</tr>
<tr>
<td>LCOE</td>
<td>baseline</td>
<td>↓2.63%</td>
<td>↓4.28%</td>
</tr>
</tbody>
</table>
DeepBlue 4.0 Pro modules offer lower BOS & LCOE, delivering greater customer value

**DeepBlue 4.0 Pro VS p-type module**
- Lower BOS: 2%-4.5%
- Lower LCOE: 2.5%-6%

**DeepBlue 4.0 Pro VS Original n-type module**
- Lower BOS: 1.4%-2.8%
- Lower LCOE: 0.7%-1.6%
DeepBlue 4.0 Series — Integration and Win-win

### 182*199mm²

1 wafer size

5 types of module

<table>
<thead>
<tr>
<th>Module Type</th>
<th>Power (W)</th>
<th>Efficiency (%)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAM54D40/LB</td>
<td>450W</td>
<td>22.5%</td>
<td>31.8</td>
</tr>
<tr>
<td>JAM66D42/LB</td>
<td>580W</td>
<td>22.5%</td>
<td>32.5</td>
</tr>
<tr>
<td>JAM72D40/LB</td>
<td>595W</td>
<td>22.5%</td>
<td>33.1</td>
</tr>
<tr>
<td>JAM66D45/LB</td>
<td>610W</td>
<td>22.5%</td>
<td>34.6</td>
</tr>
<tr>
<td>JAM72D42/LB</td>
<td>630W</td>
<td>22.5%</td>
<td>34.6</td>
</tr>
</tbody>
</table>

*(1762×1134mm) (2278×1134mm) (2333×1134mm) (2382×1134mm) (2465×1134mm)*

### Residential

- **JAM54D40/LB**: 450W/22.5% 31.8 kg
- **JAM66D42/LB**: 580W/22.5% 32.5 kg
- **JAM72D40/LB**: 595W/22.5% 33.1 kg
- **JAM66D45/LB**: 610W/22.5% 34.6 kg
- **JAM72D42/LB**: 630W/22.5% 34.6 kg

### C&I Utility-scale Applications

- **JAM54D40/LB**: 450W/22.5% 31.8 kg
- **JAM66D42/LB**: 580W/22.5% 32.5 kg
- **JAM72D40/LB**: 595W/22.5% 33.1 kg
- **JAM66D45/LB**: 610W/22.5% 34.6 kg
- **JAM72D42/LB**: 630W/22.5% 34.6 kg

4 high-efficiency modules + 1 regular module using only 1 wafer type
Harvest the Sunshine

www.jasolar.com