Status of Crystalline Silicon PERC Solar Cells

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PERC Cell’s Market Share
Learning curve for module price as a function of cumulative shipments

Fig. 1: Learning curve for module spot market price as a function of cumulative PV module shipments.
Cast Mono Si PERC Record Cell

22.8%

From Canadian Solar. Inc
Mono Si PERC Record Cell

24.03%

From Longi
Typical $p$-PERC Cell Performance

- Size: 158.75 x 158.75 mm$^2$
- Eff: 22.1%
- $P_{\text{max}}$: 5.57 W
- ASP: ¥1.01/W or ¥5.63/pc (11/2019)
- Ag consumption (mg): <100
- $V_{\text{oc}}$: 681 mV
- $J_{\text{sc}}$: 40.3 mA/cm$^2$
- FF: 80.5%
- Eff: 22.1%
- LID, LeTID?
- > 22.5%?
PERC Cell Annual Production

![Graph showing the annual production of PERC cells from 2014 to 2020, with lines for capacity, production, and average cell efficiency.](image-url)
Cell Improvements

![Graph showing cell efficiency improvements](image-url)
Global Projects

Jinko Commissioned the World's Largest Solar Project in Abu Dhabi

The world's largest solar plant of 1,177Mwp, which was jointly developed by Jinko, Japan's Mitsubishi Corp, and Emirates Water and Electricity Company (EWEC), has recently started commercial operations as scheduled at Sweihan in Abu Dhabi. The AED3.2 billion project, which uses all Jinko’s high efficient mono panels, features another record at the time of bid submission attracting the world’s most competitive tariff of 2.42 cents per kilowatt hour. In line with the Year of Tolerance in the UAE, the project - a venture between international companies managed and constructed by a multi-national team - signifies the multi-cultural essence of the Company and its ability to integrate resource and top partners from around the world.

Electricity at $0.0242/kWh

1117 MW p-PERC Cell module
Standard Back Surface Field Cell

For p-type c-Si cell

~ 20%

Limited by rear $J_0$
The 25% UNSW PERC Cell

- Inverted pyramid
- Selective emitter
- Plated fingers
- Point contact

1999 after new AM1.5 standard

Best Efficiency: 25.0%
FF: 82.8%
$V_{oc}$: 706 mV
$J_{sc}$: 42.7 mA/cm$^2$

1989: Passivated Emitter and Rear Cell (PERC)
Cell Efficiency: 22.8%
Advantages of PERC Cell

From ISFH

- Higher $V_{oc}$
- Better IR response
PERC Cell Performance Review

Best Efficiency (%)

- Schott Solar
- JA
- Sunrise Global
- Trina
- Solar World
- NSP
- Gintech
- TongWei
- Aiko
- Sumin
- Risen
- Talesun
- CSI
- Suntech
- Jinko
- Longi/Lerri
- UNSW

Year

- 1/2/1982
- 1/2/1986
- 1/2/1990
- 1/2/1994
- 1/2/1998
- 1/2/2002
- 1/2/2006
- 1/2/2010
- 1/2/2014
- 1/2/2018
- 1/2/2022

Note: The diagram shows the performance efficiency of different solar cell manufacturers over time.
PERC Cell Process in Manufacturing

1. SDR
2. Texturing
3. POCl₃ diffusion
4. Rear side etching

5. Rear Passivation layers
6. Front SiNx
7. Laser Ablation

8. Screen printing
9. Co-firing, AN & regeneration
10. JV & sorting
Factory Specs: *p*-type cell

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>&gt;22</td>
</tr>
<tr>
<td>Throughput</td>
<td>wph</td>
<td>~ 6000</td>
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<tr>
<td>Capacity</td>
<td>MW/line</td>
<td>&gt;250</td>
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<tr>
<td>Yield</td>
<td>%</td>
<td>&gt;98</td>
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<tr>
<td>Cost of cell</td>
<td>$/W</td>
<td>0.035</td>
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<tr>
<td>CapEx</td>
<td>$m/GW</td>
<td>~ 40</td>
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<tr>
<td>Size</td>
<td></td>
<td>&lt; M6, M12</td>
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</table>
Light Induced Degradation (LID)

Monocrystalline PERC Cell

Before LID, 20.924%

After LID, 19.293%

Δ 5.42%

Testing Condition

➢ Illumination intensity at 900-1000 W/m²

➢ Cell temperature at 50-60°C

➢ Light Soaking for 5 hours

<table>
<thead>
<tr>
<th>c-Si PERC Cell</th>
<th>Before LID</th>
<th>After LID</th>
<th>Δ</th>
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<tbody>
<tr>
<td>Efficiency (%)</td>
<td>20.92%</td>
<td>19.79%</td>
<td>5.42%</td>
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</tbody>
</table>
Q-Cell Report

Regeneration of Defects

Photon injection

Heater

Cell

1 – 100 suns

LED/Laser

Carrier injection

Axel Herguth and Giso Hahn, 
*EU PVSEC 2013*)
Figure Out the Root Cause of LeTID

Alex Herguth, and Brett Hallam, from: 28th Workshop on c-Si solar cells and Modules
# Cell Size Gets Larger

The table below shows the dimensions and changes of different units:

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>M2</th>
<th>G1</th>
<th>M6</th>
<th>M12</th>
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<tbody>
<tr>
<td>Diameter</td>
<td>mm</td>
<td>211.0</td>
<td>223.0</td>
<td>223.0</td>
<td>304.8</td>
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<tr>
<td>Length</td>
<td>mm</td>
<td>156.75</td>
<td>158.75</td>
<td>166.00</td>
<td>210.00</td>
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<tr>
<td>Area</td>
<td>cm²</td>
<td>244.31</td>
<td>252.01</td>
<td>274.16</td>
<td>441.00</td>
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<td>Change</td>
<td>cm²</td>
<td>0.00</td>
<td>7.70</td>
<td>29.85</td>
<td>196.69</td>
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<tr>
<td>Change</td>
<td>%</td>
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<td>3</td>
<td>12</td>
<td>80</td>
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<td>Change</td>
<td>%</td>
<td>0</td>
<td>9</td>
<td>75</td>
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<tr>
<td>Change</td>
<td>%</td>
<td>0</td>
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<td>71</td>
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</tbody>
</table>
Module Trend

2018

400W

2019

>450W

2020

500W?
Applications

Highway sound barrier

Above water
Thank You!