PERC Bifacial PV
BiFi cell, module, and system

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Sep. 29, 2016

bifiPV2016 workshop at Miyazaki
Outline

- Market of Bifacial PV and PERC
- Bifacial solar cell and module technologies
- NSP’s BiFi cell and module products
- System IRR comparison
- Summary
Bifacial market share 15% in 2020
ITRPV roadmap 2016

Bifacial PV market share is forecasted to be 15% in 2020. However, its growth rate is quite slow in reality.

High cost is main issue for expanding market share of bifacial PV.
# Bifacial solar cell and module technology comparison on material and tools invest

<table>
<thead>
<tr>
<th></th>
<th>nPERT/nPERL</th>
<th>SHJ</th>
<th>PERC BiFi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell Eff.</strong></td>
<td>21.x%</td>
<td>22.x%~23.x%</td>
<td>21.x%</td>
</tr>
<tr>
<td><strong>Wafer type</strong></td>
<td>6” N-type</td>
<td>5”/6” N-type</td>
<td>6” P-type</td>
</tr>
<tr>
<td><strong>Ag usage</strong></td>
<td>Double-side Ag</td>
<td>Double-side Ag</td>
<td>One-side Ag</td>
</tr>
<tr>
<td><strong>Cell Tools</strong></td>
<td>New tools + Existing tools</td>
<td>New tools</td>
<td>Existing tools</td>
</tr>
<tr>
<td><strong>Module Tools</strong></td>
<td>Existing tools</td>
<td>New soldering</td>
<td>Existing tools</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

- nPERT/nPERL/SHJ are using **high-cost n-wafers and double-sided Ag paste**.
- nPERT/nPERL/SHJ cell and module process need **more tool investment** than PERC BiFi.
- PERC bifacial is using **existing process tools and same materials as pPERC**, enabling **cost reduction** for bifacial PV.
PERC market share is forecasted to be 25% in 2020.

PERC bifacial can be a new way for expanding market share of bifacial PV by leveraging PERC technology.
Black21_BiFi
P-type PERC bifacial solar cell

Black21_BiFi is a p-type PERC bifacial solar cell with 21.2% front-side efficiency and bifaciality=65%.
Equivalent eff. = 23.96%  
assuming albedo 20%

Cell eff. = 21.2%_{front} + 13.8%_{rear} \times 20\%_{Albedo} = 23.96\%_{equ-eff.
21.2% Black21_BiFi cell electrical parameters

<table>
<thead>
<tr>
<th></th>
<th>Champion</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voc</td>
<td>674.4 mV</td>
<td>673.0 mV</td>
</tr>
<tr>
<td>Isc</td>
<td>9.75 A</td>
<td>9.74 A</td>
</tr>
<tr>
<td>FF</td>
<td>78.81%</td>
<td>78.44%</td>
</tr>
<tr>
<td>eff.</td>
<td>21.2%</td>
<td>21.0%</td>
</tr>
</tbody>
</table>

in-house test with reference cell from third-party certificate

- 21.2% 4BB BiFi cell efficiency has been achieved.
337W equivalent power double-glass BiFi module

- **Power Output**
  - Front-side power 298W (60 cells)
  - Equivalent power 337W (20% albedo)

- **Reliability**
  - Double-Glass Protection for Cells
  - 3X IEC test level
    - DH3000hrs/TCT600cycles
  - 1500V/Anti-PID

- BiFi double glass module enables higher power output and better reliability.
### 298.1W_\text{F}/194.2W_\text{R} power certificate

<table>
<thead>
<tr>
<th>B21_BiFi cell eff.</th>
<th>21.0% eff. x 60 cells</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front power</strong></td>
<td><strong>298.1W</strong></td>
</tr>
<tr>
<td>Voc=39.8V; Isc=9.9A; FF=75.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Rear power</strong></td>
<td><strong>194.2W</strong></td>
</tr>
<tr>
<td><strong>Bifaciality</strong></td>
<td><strong>65.1%</strong></td>
</tr>
<tr>
<td><strong>Equ. Power</strong></td>
<td><strong>337.0W</strong></td>
</tr>
<tr>
<td>Front+Rear x Albedo (Albedo=20%)</td>
<td></td>
</tr>
</tbody>
</table>

Certificated by third party.

- **337.0W** equivalent power with **298.1W_\text{F}/194.2W_\text{R}** was certificated by third party.
## Equivalent power of BiFi module

<table>
<thead>
<tr>
<th>Ground Condition</th>
<th>Gray pavement</th>
<th>Grass</th>
<th>White paint</th>
<th>Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albedo</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40~80%</td>
</tr>
<tr>
<td>Equivalent Power Front-side</td>
<td>298W</td>
<td>337W</td>
<td>356W</td>
<td>&gt;375W</td>
</tr>
</tbody>
</table>

- Equivalent power BiFi module is **337W**, assuming albedo=20%.
- Equivalent power BiFi module is **356W**, assuming albedo=30%.
5 benefits from BiFi module

- **Benefit1**: High-Power output $298W_F$ and equivalent $337W$
- **Benefit2**: 3X IEC (30yrs) reliability, low degradation rate, and high fire-resistance
- **Benefit3**: 1500V/anti-PID, saving cost in inverter and grounding
- **Benefit4**: Aesthetic appearance with double glass
- **Benefit5**: Higher system IRR than conventional c-Si modules
IRR simulation for BiFi system

- ChangHua (彰化) Taiwan
- Ground type 500 kW
- Leverage from bank
  - Bank loan percentage: 70%
  - Interest Rate: 3.5%
  - Years of loan: 15 years
- 2017 FIT condition:
  - NTD 4.4/kWh multi
  - NTD 4.62/kWh incentive for >295W module
- Modules to compare
  - 265W Multi c-Si
  - 280W Mono c-Si
  - 295W PERC mono
  - 295W PERC BiFi
System IRR comparison

- **NSP BiFi 295W** module enables **higher system IRR** than conventional mono-facial 265W multi c-Si, 280W mono c-Si, and 295W PERC modules.
- **Higher albedo** enables **higher IRR** in BiFi system.
Various application of double-glass BiFi module

- **BiFi module has various applications** in solar farm, agriculture, flat rooftop, BIPV, carport, landmark, snow region, and desert region.
Cost reduction is the key to expand bifacial PV market. PERC bifacial technology is a new way to achieve high-power and low-cost module.

NSP BiFi double-glass module has high power output and better reliability.

- Champion cell efficiency 21.2%
- Champion module power 298W with 60 cells and equivalent power 337W.

NSP BiFi module enables higher system IRR than conventional mono-facial multi c-Si, mono c-Si, and PERC modules.
Visit NSP’s booth in PV Taiwan 2016
Oct. 12-14 at Taipei
Thank You
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