## Exiting times for Scatec Solar this fall

<table>
<thead>
<tr>
<th>Plant</th>
<th>MW</th>
<th>SSO %</th>
<th>2H’17</th>
<th>1H’18</th>
<th>2H’18</th>
<th>1H’19</th>
<th>2H’19</th>
<th>20+ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>197</td>
<td>68%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>162</td>
<td>44%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honduras</td>
<td>35</td>
<td>70%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>40</td>
<td>52%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>400</td>
<td>51%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>258</td>
<td>42%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,092</td>
<td>52%</td>
<td>Construction</td>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Construction start / Expected construction start**
- **Expected grid connection**
On track to deliver 1.1GW… and ready for more!
Overview of the different technologies for silicon solar cells and module assembly

- **Materials**
  - Multi/Polycrystalline
  - Monocrystalline
  - P-type
  - N-type

- **Cell structures technologies:**
  - AI-BSF (Aluminum Back Surface Field)
  - PERC (Passivated Emitter and Rear Cell)
  - PERL (Passivated Emitter, Rear Locally diffused)
  - PERT (Passivated Emitter, Rear Totally diffused)
  - HIT (Heterojunction with Intrinsic Thin layer)
  - IBC (Interdigitated Back Contact)

- **New cell-to-module technologies**
  - Multi Bus Bar (MBB)
  - Bi-facial
  - Half cut cell
  - Shingles cells
  - Light reflecting ribbons
Mono will continue to take market share from poly

1. Mono up, multi down

- 2018-2022 likely to represent the full mono-to-multi transition phase.
- Mono enables PERC.
- PERC enables bifaciality.
- Mono allows more efficiency enablers on cells/modules.
- Mono wafers allow n-type variants to grow faster.
## Cell structures technologies and their efficiencies today

<table>
<thead>
<tr>
<th></th>
<th>AI-BSF</th>
<th>PERC</th>
<th>PERL</th>
<th>PERT</th>
<th>HIT</th>
<th>IBC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell structure</strong></td>
<td>Aluminum Back Surface Field</td>
<td>Passivated Emitter and Rear Cell</td>
<td>Passivated Emitter, Rear Locally diffused</td>
<td>Passivated Emitter, Rear Totally diffused</td>
<td>Heterojunction with Intrinsic Thin layer</td>
<td>Interdigitated Back Contact</td>
</tr>
<tr>
<td><strong>Diagram</strong></td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>This is the traditional solar cell structure widely used on utility scale plants.</td>
<td>Passivation layer on rear contact reduces surface recombination and reflects photons back into the wafer.</td>
<td>Adding local BSF to the PERC cell openings further reduces recombination and increase efficiency.</td>
<td>Fully diffused layer adjacent to the passivation layer further reduces recombination and increase efficiency.</td>
<td>HIT cells are using amorphous silicon for passivation purposes, hence the name heterojunction.</td>
<td>IBC cells move the emitter to the rear allowing both contacts to sit at the bottom while the front side is fully exposed to light.</td>
</tr>
<tr>
<td><strong>Layer Characteristics</strong></td>
<td>P-type poly &amp; mono</td>
<td>P-type poly &amp; mono</td>
<td>P-type mono</td>
<td>N-type mono</td>
<td>N-type mono</td>
<td>N-type mono</td>
</tr>
<tr>
<td><strong>Typical Cell Efficiency</strong></td>
<td>Typically 18% cell efficiency (poly)</td>
<td>Typically 1% increased cell efficiency over AI-BSF (mono: 20%)</td>
<td>Typically 0.5% increased cell efficiency over PERC (20.5%)</td>
<td>Typically 1% increased cell efficiency over mono PERC (21%)</td>
<td>Typically 2% increased cell efficiency over mono PERC (22%)</td>
<td>Typically 3% increased cell efficiency over mono PERC (23%)</td>
</tr>
<tr>
<td><strong>Module Power</strong></td>
<td>72c module @ 325W</td>
<td>72c module @ 355W</td>
<td>72c module @ 360W</td>
<td>72c module @ 370W</td>
<td>72c module @ 390W</td>
<td>72c module @ 410W</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>High availability (Trina, Jinko, Longi ++)</td>
<td>High availability (Trina, Jinko, Longi ++)</td>
<td>Low availability (JA Percium series is dominating)</td>
<td>Many suppliers but relative low volume. (LG, Yangli, Imec)</td>
<td>Low availability, (Panasonic HIT-series is dominating)</td>
<td>Low availability, (SunPower X-series, LG P-series)</td>
</tr>
</tbody>
</table>
Higher efficiency cell technology will dominate

Figure 37: Market share of different c-Si solar cells

Source: Bloomberg NEF
# New cell-to-module technologies and their power gains

<table>
<thead>
<tr>
<th>Bi-facial</th>
<th>Multi Busbar (MBB)</th>
<th>Half cut (HC) cell</th>
<th>Shingle cells</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Bi-facial module" /></td>
<td><img src="image" alt="Multi Busbar (MBB)" /></td>
<td><img src="image" alt="Half cut (HC) cell" /></td>
<td><img src="image" alt="Shingle cells" /></td>
</tr>
<tr>
<td>Bi-facial modules can absorb light also from the back side of the module.</td>
<td>By adding more busbars the electrical losses in the fingers are reduced as the current needs to travel shorter distance to the nearest busbar.</td>
<td>By cutting the cell in two the busbar current is reduced by 2 and thus reducing the I2R losses by 4.</td>
<td>Overlapping cells with hidden busbars increased the available sun-facing area of the module.</td>
</tr>
<tr>
<td>Can be combined with PERC, PERT, HIT and IBC cells.</td>
<td>Poly or mono cells</td>
<td>Poly or mono cells</td>
<td>Poly or mono cells</td>
</tr>
<tr>
<td>Efficiency depending on ground albedo. Typically 10% increase in module efficiency with 30% albedo.  <strong>72c module @ +35W</strong></td>
<td>12BB has 2% increased cell efficiency over 4BB cell. <strong>72c module @ +30W</strong></td>
<td>Module efficiency increased by 3%. <strong>72c module @ +10W</strong></td>
<td>Module efficiency increased by 6%. <strong>72c module @ +20W</strong></td>
</tr>
<tr>
<td>High availability from 2018 as PERC can easily adapted for bi-facial production.</td>
<td>Limited availability due to high manufacturing cost. <strong>72c module @ +35W</strong></td>
<td>Medium availability, increasing from 2018. All SMSL vendors are introducing this technology now. <strong>72c module @ +10W</strong></td>
<td>Low availability, increasing from 2018. SunPower P-series already in production. Longi has launched. <strong>72c module @ +20W</strong></td>
</tr>
</tbody>
</table>
Product examples – new technologies

LG n-type PERT MBB
400W @72cell

First Solar Series-6 (a-Si thinfilm)
Corresponding to 370W @72cell

Panasonic HIT
330W @60cell

Sunpower X-series (IBC)
340W @60cell

Sunpower P-series (shingle)
355W @72cell
Bi-facial modules

**LONGi Solar**

LR6-72BP

350~370W

Hi-MO2 High Efficiency Low LID Bifacial PERC Technology
Best Solution for Lower LCOE

**Longi mono PERC**

370W @72cell
75% bifaciality

**Sunpreme n-type HCT half-cut cell**

400W @72cell
90% bifaciality
Cell efficiency continues to grow. We can expect another 8% increase over the next 4 years for mono cells.

Historically:
Cell efficiency increased by 12% (mono) and 10% (multi) over the last 5 years

Supplier roadmap 1 (Longi):
Longi expect mono PERC efficiency to increase by 8% during 2021

Supplier roadmap 2 (Jinko):
Jinko expect mono PERC efficiency to increase by 7.5% during 2021
Fresh update from Bloomberg confirms the continued increase in module efficiency in 2018
Self powered and wireless trackers will reduce EPC cost

- Solar Tracker Global Installations:
  - 2017 14.5GW shipped
  - Expected >20% annual growth from 2017-2021

- Major cost drivers on BOS reduction
  - Wireless communication
  - Self Powered tracking
  - Optimized tracking algorithm
  - Robust DC drives and battery systems.
  - Cleaning robots
  - Predictive O&M

- Trends in Technology:
  - Globally tracker majority of installed capacity is moving to **single drive trackers**. It is expected to be the dominant technology type.
  - **Bifacial trackers** expected to rapidly grow in installed capacity in the next 5 years.
  - **Wireless technology** not yet considered fail safe with most companies offering wired options.
  - **Simulation software** for bifacial trackers expected to be available towards end of 2018.
Inverter development

- We expect continues incremental improvements and cost reductions in solar inverters;
  - Silicon carbide (SiC) technology in power electronics allows for higher switching frequency, thus reducing the size and cost of passive components (inductors, capacitors).
  - Multilevel topologies is already deployed in String Inverters (e.g. Huawei), but we expect this also to find its way into central inverters.
  - Central inverters continue to increase in power rating and increasing block size.
  - Using composite materials and optimized assembly technologies will reduce power-to-weight ratio
  - Smart monitoring for early failure detection and increased reliability.
  - «Virtual central inverter» introduced by Sungrow
    - BOS benefits from central inverter
    - Flexibility of the string inverter
Business models

• Traditional – PPA with 25y duration
• Energy storage – typically part of LCOE and not separate revenue streams
• Hybrid solutions – private PPA (build-own-operate-transfer) or leasing contracts
• Merchant market – not there yet, although some examples exist
• Re-deployable energy – promising technology for short term private PPAs
Re-deployable solar systems

Easy to redeploy

4x faster to install vs. traditional solar