Performance and Reliability Evaluation of CPV Systems

Mani G. TamizhMani
ASU-Photovoltaic Reliability Laboratory
Presentation Objective
To provide objective field evidence why accurate **LONG-TERM tracking** and **NON-ADJUSTABLE misalignment** issues are extremely critical for the success of high concentration CPV systems.
Outline

- System Description
- Performance and Reliability Results
- Key findings
- Conclusions
System Description
<table>
<thead>
<tr>
<th>Site</th>
<th>Size (kW&lt;sub&gt;DC&lt;/sub&gt;)</th>
<th>Age (y)</th>
<th>Concentration</th>
<th>Module Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>160</td>
<td>2.25</td>
<td>1300x</td>
<td>900 W/m&lt;sup&gt;2&lt;/sup&gt; DNI, 25°C Cell T</td>
</tr>
<tr>
<td>Plant 2</td>
<td>272</td>
<td>2</td>
<td></td>
<td>250 W</td>
</tr>
<tr>
<td>Plant 3</td>
<td>144</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Controller software adjusts the tracking of:
- Array
- Strings in an array
- Paddles in a string

…..but not of:
- Modules in a paddle
- Optics in a module
- Receivers/cells in a module

Note: I-V curves were translated with a voltage temperature coefficient of -99.1 mV/°C (-0.12%/°C) and a current temperature coefficient of 2.34 mA/°C (0%/°C) assuming heat-sink temperature is equal to cell temperature.
Performance and Reliability Results
Plant 1

Best string capacity = 79%
Non-adjustable HARDWARE issue = 21% loss
(Intrinsic issue)

Note: Intrinsic issue is probably caused by the misalignment and/or degradation of optics and/or receivers/cells due to thermal cycling stresses which cannot be fixed in the field.

Potential gain if each string is adjusted to best string performance using tracker controller SOFTWARE and adjustable hardware
(Extrinsic issue)
Best string capacity = 62% (has potential to be improved to 79% - see previous slide)

Important note: After manual alignment of strings and paddles (not modules or receivers) using a sundial and pyrheliometer, a few of the bad strings gained power but not to the full 100% capacity. The 100% non-recovery issue could be due to combination of two reasons: intrinsic issue (see previous slide) and inaccuracy in our manual alignment using unsophisticated mechanical sundial and 5° full view angle based pyrheliometer which are not sufficient for these 1300X CPV designs.
Plant 3

Best string capacity = 51% (has potential to be improved to 79% - see slide 7)
**$P_{\text{max}}$ of Individual Modules**

(32 modules individually tested; modules are from the best array based on inverter kWh data)

<table>
<thead>
<tr>
<th>Module Rating</th>
<th>900 W/m² DNI, 25°C Cell T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated $P_{\text{max}}$</td>
<td>250 W</td>
</tr>
</tbody>
</table>

Best module capacity = 79%; Non-adjustable HARDWARE issue = 21% loss

(Intrinsic issue)

Note: Intrinsic issue is probably caused by the misalignment and/or degradation of optics and/or receivers/cells due to thermal cycling stresses which cannot be fixed in the field.
Key Findings

- Best string and best module are operating at about 79% of rated capacity.

- 7 out of 36 arrays in all three power plants are not producing any power at all
  - Indicated a severe off-axis tracking issues on 7 arrays

- The best performing array operates at 70% of the rated capacity; all working arrays (29 out of 36) are underperforming at less than 70% of the rated capacity
  - Indicated that the strings, paddles and/or modules are having serious misalignment issues

- On an average, all operating and non-operating arrays (36 arrays) are working at **41% of rated capacity (Just less than 2 years old!)**
  - Indicated that the strings, paddles and/or modules (optics and receivers) are having serious misalignment issues
Conclusions

Alignment of 24 receivers/cells within a module

Alignment of 8 modules within a paddle

Alignment of 2 paddles within a string

Alignment of 4 strings within an array

Presentation Objective
To provide objective field evidence why accurate LONG-TERM tracking and NON-ADJUSTABLE misalignment issues are extremely critical for the success of high concentration CPV systems.
Thanks for your attention!

Contact:
Mani G. TamizhMani
manit@asu.edu