



Performance and Reliability Evaluation of CPV Systems

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Designed Plant



Operating Plant



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

Site	Size (kW _{DC})	Age (y)	Concentration	1300x (tracking resolution 0.1°)
Plant 1	160	2.25	Module Rating Rated P _{max}	900 W/m ² DNI, 25°C Cell T 250 W
Plant 2	272	2		
Plant 3	144	1		

Array per Inverter with 4 strings

Four East Paddles

Four West Paddles

String with 2 paddles

Paddle with 8 Modules

Site 1: 10 inverters = 40 strings = 10 x 4 x 2 x 8 modules = 640 modules

Site 2: 17 inverters = 68 strings = 17 x 4 x 2 x 8 modules = 1088 modules

Site 3: 9 inverters = 36 strings = 9 x 4 x 2 x 8 modules = 576 modules

Controller software adjusts the tracking of:

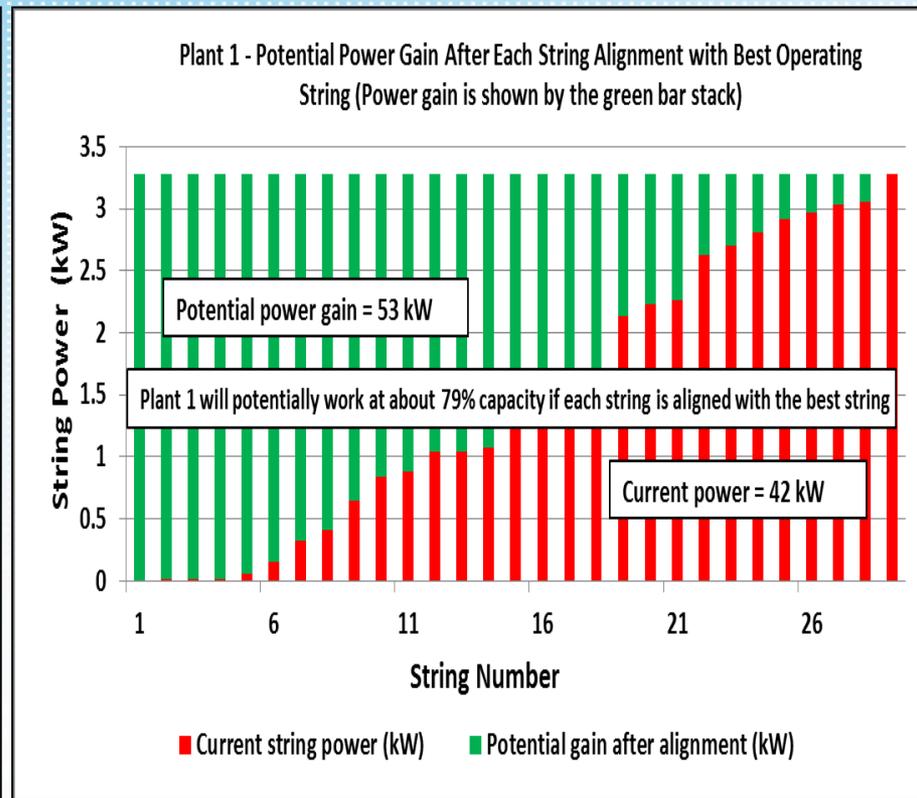
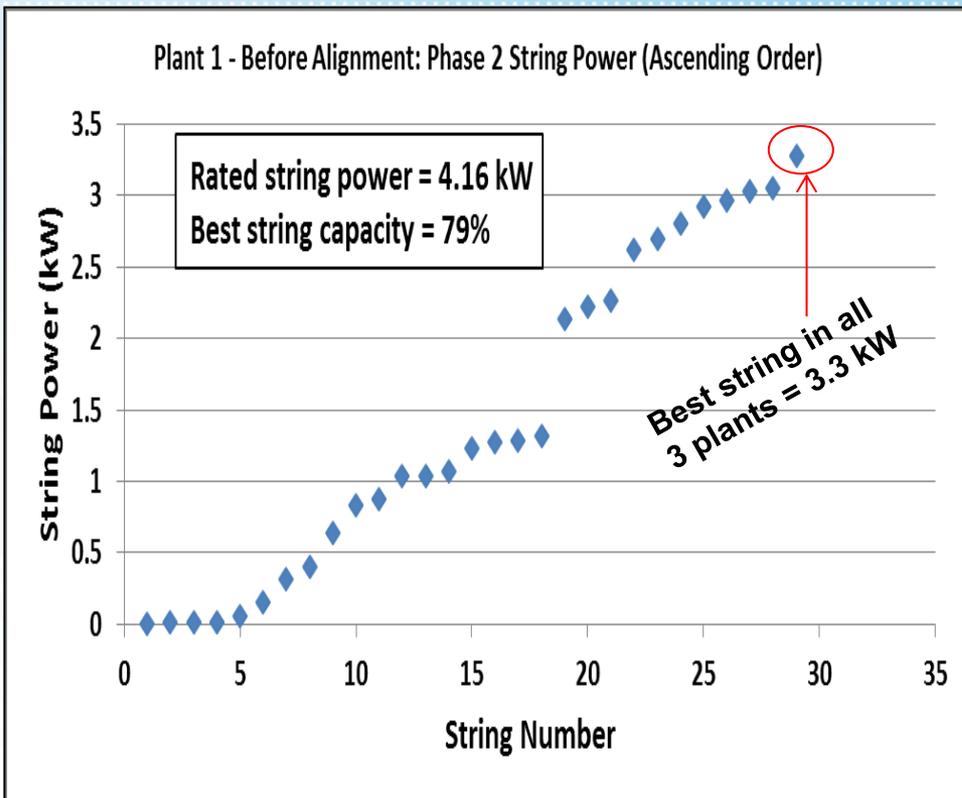
- Array
- Strings in an array
- Paddles in a string
.....but not of:
- Modules in a paddle
- Optics in a module
- Receivers/cells in a module

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)

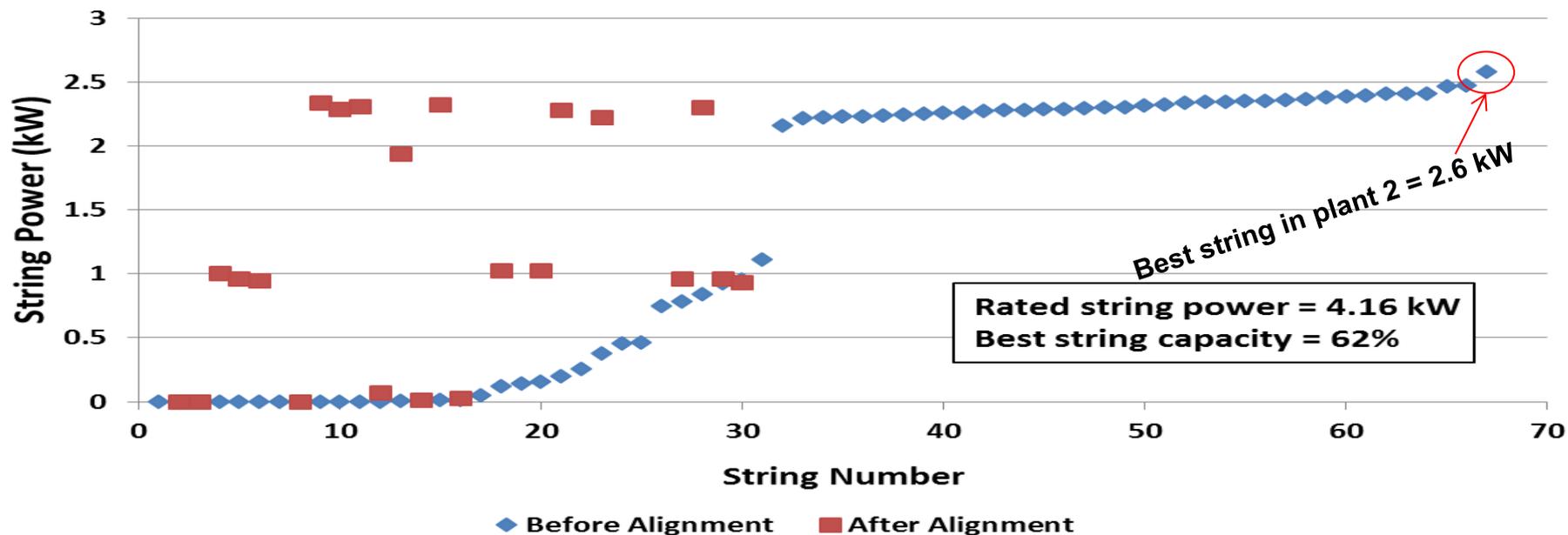
Potential gain if each string is adjusted to best string performance using tracker controller SOFTWARE and adjustable hardware

(Extrinsic 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.

Plant 2

Plant 2 - Before and After Alignment: Phase 2 String Power (Ascending Order)

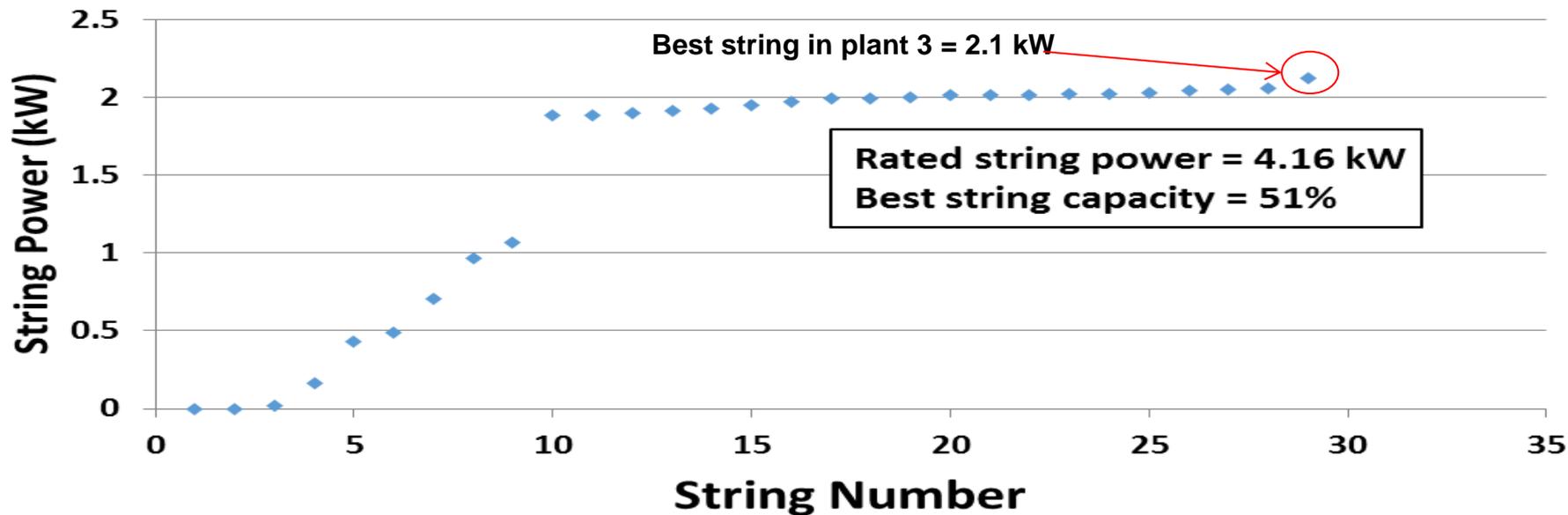


Best string capacity = 62% (has potential to be improved to 79% - see previous slide)

Important note: After manual alignment of strings and paddles (not modules or receivers) using a sundial and pyrhelimeter, 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 pyrhelimeter which are not sufficient for these 1300X CPV designs..

Plant 3

Plant 3 - Before Alignment: Phase 2 String Power (Ascending Order)



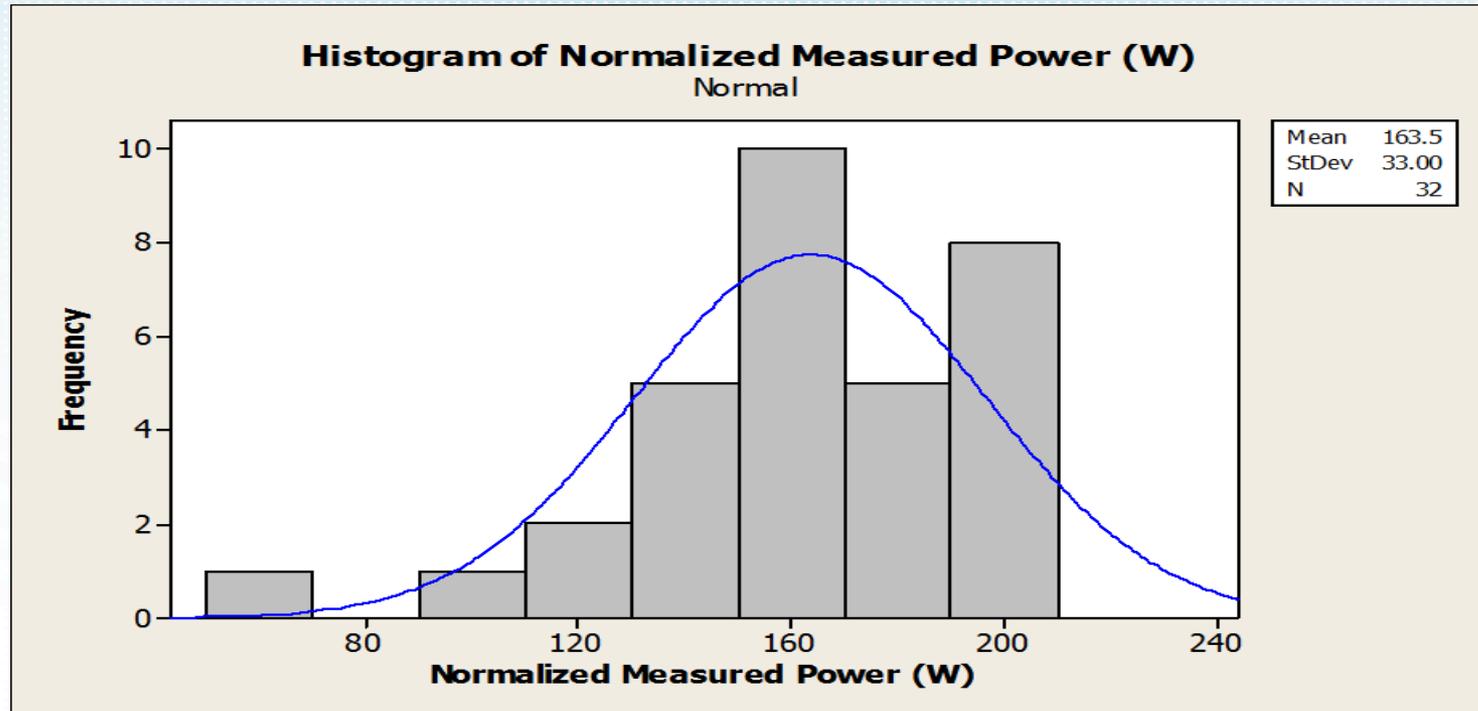
Best string capacity = 51% (has potential to be improved to 79% - see slide 7)

P_{max} of Individual Modules

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

Module Rating 900 W/m² DNI, 25°C Cell T

Rated P_{max} 250 W



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

INTRINSIC Alignment Issues
(cannot be adjusted
by tracker controller)

Second order issue: Non-adjustable hardware

EXTRINSIC Alignment Issues
(can be adjusted
by tracker controller)

First order issue: Complex software

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Thanks for your attention!

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