American-Made Solar Prize -- Technical Assistance Request

Project: Floating Solar PV Breakthrough

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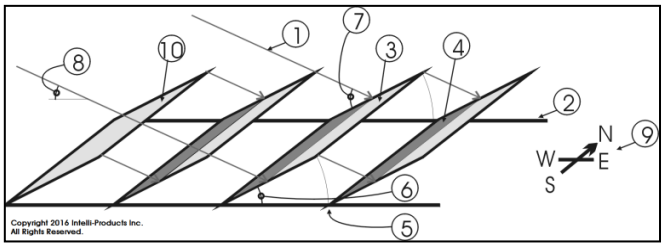
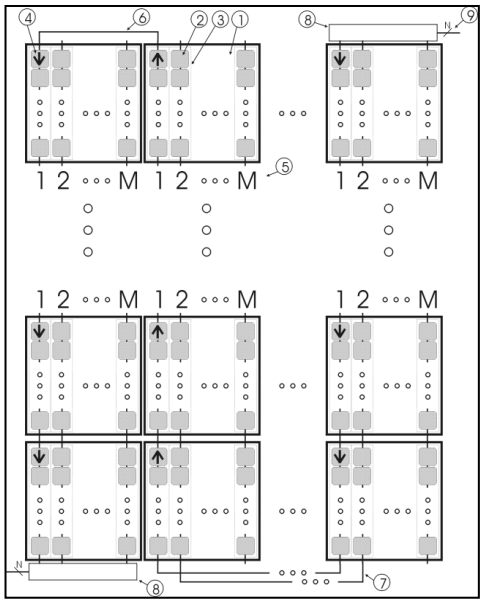
We are bringing Floating Tracking Solar PV to market intended to implement the now common East-West Tracking scheme. Inherent in this new Floating PV (FPV) solution is a relatively tighter inter-row spacing than would typically be used on land. As part of the innovation, we have envisioned and tested one idea of how to maximize overall PV Array Output in the scheme of intentional parallel inter-row shading as shown here which will occur in the early morning and late afternoon in any such tracking array. The same issue and innovation presented here would benefit current land-based Tracking PV by reducing the amount of inter-row spacing needed and potentially open new Tracking Arrays opportunities for building rooftops.



The innovation stems from having tested a PV Cell in full sun and full shade under clear sky conditions, and we discovered that the power output in "full shade" conditions was about 54% of that in full-sun. By full-shade, we mean in complete shade but with a clear bright sky view. The cell used was fairly old and blue in color with an unknown cell composition.

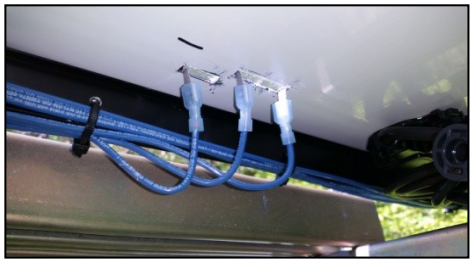


Based on that finding, we proposed a Shade-Common intra-panel parallel wiring scheme as shown here to allow densely spaced 1-axis tracking with greater power output. This graphic shows the innovation at the "cell row" level where individual rows of cells in each panel are accessible. However, the basic concept is also applicable to any tracking array more than one panel in width where each "longitudinal panel row" is a separate circuit "string" which could be implemented with any tracking array.

A mathematical analysis (below graphics and results table) was completed based on the experimental output potential of 54% for shaded cells in densely spaced tracking arrays on the assumption that the power output from each row of commonly shaded PV (cells or whole panels) could be optimally converted -- i.e., different V-I characteristics hence

Panel Configuration	Upper Tilt Limit	East-West Gap	North-South Gap	Cover	Relative Output per Panel	Relative Output per Acre (re Flat)	Relative Output per Acre (re Pole)	Analysis: Combined 50%/50% Panel/Acre Output
Flat to ground	N/A	0%	0%	100%	100.0%	**100.0%**	227.0%	**100.0%**
1-axis strings	N/A	0%	40%	71%	118.8%	84.9%	192.7%	101.9%
2-axis on pole	90°	100%	80%	28%	158.6%	44.0%	**100.0%**	101.3%
2-axis on pole	90°	125%	80%	25%	161.3%	39.8%	90.4%	100.6%
Advanced PV	60°	0%	0%	100%	148.7%	148.7%	337.6%	148.7%
Advanced PV	**75°**	**0%**	**0%**	**100%**	**150.1%**	**150.1%**	**340.8%**	**150.1%**
Advanced PV	80°	0%	0%	100%	150.3%	150.3%	341.1%	150.3%

would benefit from separate Maximum Power Point Tracking (MPPT).



To test this paradigm, we constructed a Densely Spaced Tracking Test Rack as shown here. Two rows were used to ensure we can obtain the necessary full-sun/full-shade capability as can be seen in this photo (note panel shadows on right hand row). One of the panels on the left tracking row is active (data collected), and the two panels on the right tracking row are the specially adapted panels for the Shade-Enabled circuit testing (testing separate cell-rows idea) -- note the individual cell-rows circuit access shown in the photo here. We also constructed a relay "circuit selection" rack to allow individual circuit testing as well as combined testing in both series and parallel circuit patterns.

We found two significant results. First, we observed that the "black" panels we obtained from our EPC associate do not behave the same as the "blue" PV cell we originally experimented with, showing a far lower full-shade output. This suggests further testing with other cells is needed, especially focusing on cells known to have a good 'clear sky' output which is likely related to the UV response.

The second significant finding we appear to be seeing is that when a fully sun lit cell row and one fully in shade (on a bright sun day) are wired in parallel, the current output is larger than the sum of the two cell rows tested in isolation. We know of no possible cause for this other than that the added bias voltage from the fully lit cell row must be affecting the power output from the shaded cells, and we assume the same would be true for "panel rows" in inter-row shading. If this is true, then it is a potentially significant finding for the PV field. We have explored the readily available research and have not found anything associated with parallel PV shading under full sun and full shade clear sky conditions.

We conclude our intentional parallel shading findings warrant further research and hope to team with an appropriate DOE lab for that work. We do have pending patents filed for this, thus it "could" represent a new U.S. owned PV breakthrough. If proven correct for at least certain PV Cell Technologies, this would represent a significant breakthrough for PV Array Output in areas with limited space, or in general more output in any space as PV Panel prices continue to drop and more panels could be economically installed at all array sites.