ENERTIS Applus+

Prepared for

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Enhancing Accuracy in Bifacial Photovoltaic Performance Modeling under Dual Axis Tracking Constraints

Vivek Vinod Balani Mahtani

AGENDA

1. Introduction
2. Methodology
3. Results and discussion
4. Conclusions

What was the starting point of this work? → Client asked for a DAT Energy Production Estimate

What were the limitations for this EPE? → Bifacial modules

How did we overcome this limitation?

1. Monofacial simulation with DAT using PVSyst to obtain the azimuth and tilt angles of the photovoltaic plane.

Estimated 7 azimuths (deg)					
Jan	Feb	Mar	Apr	May	Jun
-57.11	-66.34	-82.62	-99.65	-114.37	-119.44
-38.12	-43.49	-55.15	-66.22	-76.87	-79.53
-19.14	-20.64	-27.67	-32.79	-39.38	-39.63
-0.15	2.21	-0.20	0.64	-1.88	0.28
18.84	25.06	27.28	34.07	35.62	40.19
37.82	47.90	54.75	67.50	73.11	80.09
56.807	70.754	82.224	100.93	110.61	120
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
-117.94	-104.70	-92.10	-73.74	-57.09	-53.42
-78.56	-69.71	-61.91	-49.46	-37.28	-36.25
-39.18	-34.71	-31.71	-25.17	-17.47	-19.07
0.21	0.28	-1.52	-0.89	2.35	-1.90
39.59	35.27	28.67	23.39	22.16	15.28
78.97	70.27	58.87	47.67	41.98	32.45
118.35	105.26	89.064	71.956	61.792	49.629

Month	Average Tilt
Jan	60.00
Feb	59.36
Mar	55.70
Apr	51.29
May	48.03
Jun	46.71
Jul	47.60
Aug	49.62
Sep	54.11
Oct	58.27
Nov	59.99
Dec	60.00

How did we overcome this limitation?

1. Monofacial simulation with DAT using PVSyst to obtain the azimuth and tilt angles of the photovoltaic plane.
2. Sequential simulations with fixed tilt (FT) using PVSyst with monofacial and bifacial modules and varying azimuth and tilt angles according to each month.

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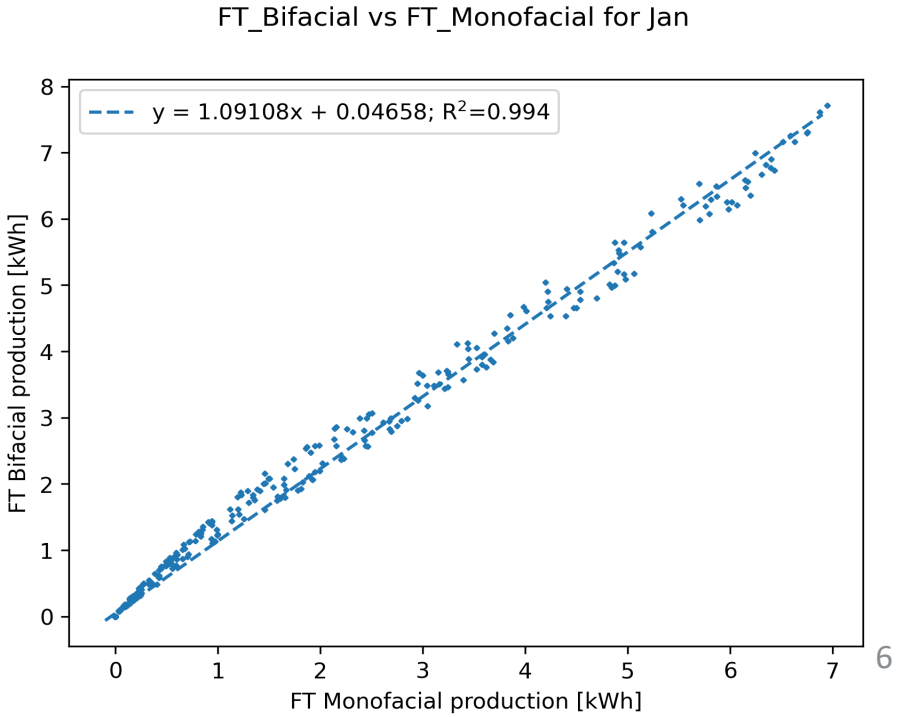
3. Integration of the results using linear regression to relate the monofacial and bifacial energy production for each month.

Month	Total Mono	Total Bif	Gain	Equation to be applied
Jan	614.5	705.1	14.75%	1.09108 x + 0.04658
Feb	759.9	906.2	19.26%	1.14056 x + 0.05884
Mar	958.5	1150.0	19.98%	1.14536 x + 0.07011
Apr	1084.7	1181.5	8.93%	1.06111 x + 0.04246
May	1241.9	1331.1	7.18%	1.05084 x + 0.03500
Jun	1271.2	1362.0	7.15%	1.05261 x + 0.03329
Jul	1364.1	1457.8	6.87%	1.05542 x + 0.02429
Aug	1289.6	1371.8	6.38%	1.04995 x + 0.02398
Sep	1044.3	1111.6	6.44%	1.04597 x + 0.02673
Oct	697.1	745.2	6.90%	1.03614 x + 0.03076
Nov	502.9	543.2	8.02%	1.03531 x + 0.03136
Dec	411.7	474.2	15.18%	1.06955 x + 0.04551
Total	**11240.4**	**12339.8**	**9.78%**	



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4. Application of the equations to the DAT energy production to estimate the bifacial gain.

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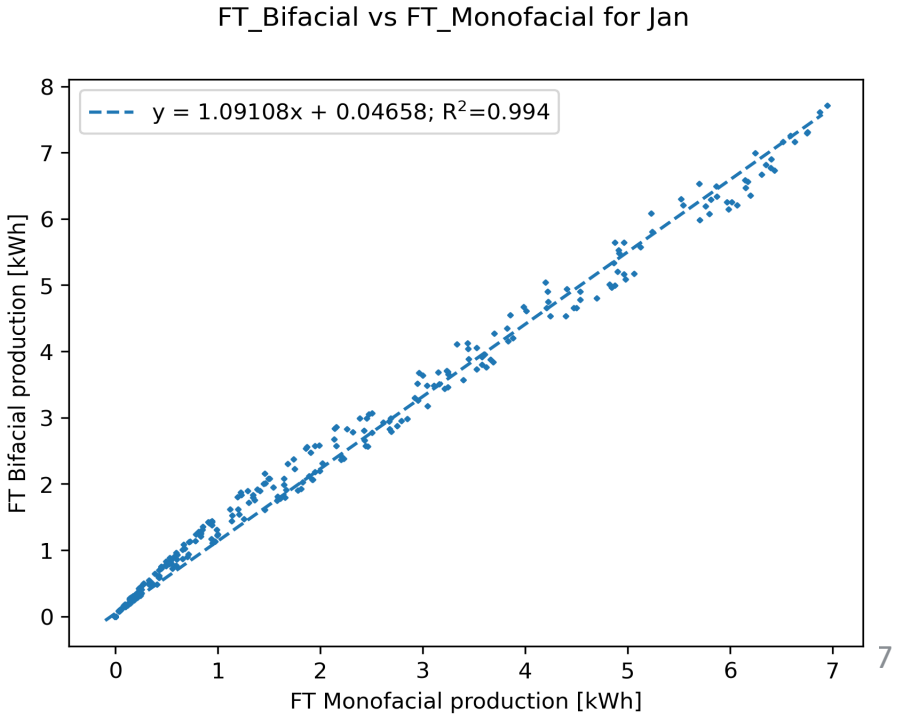

What did we do to check this methodology?

We compared the results with real bifacial gains in the literature (Burnham et al. 2019)* :

1. We simulated the 2 systems proposed in the research (modules with 60% and 90% bifaciality) with TMY data from the same location (Vermont).
2. We calculated the bifacial gain of the 2 systems and compared the simulation results with the results reported by the authors.

*Burnham, L., Riley, D., Walker, B., and Pearce, J. (2019). Performance of bifacial photovoltaic modules on a dual-axis tracker in a high-latitude, high-albedo environment.

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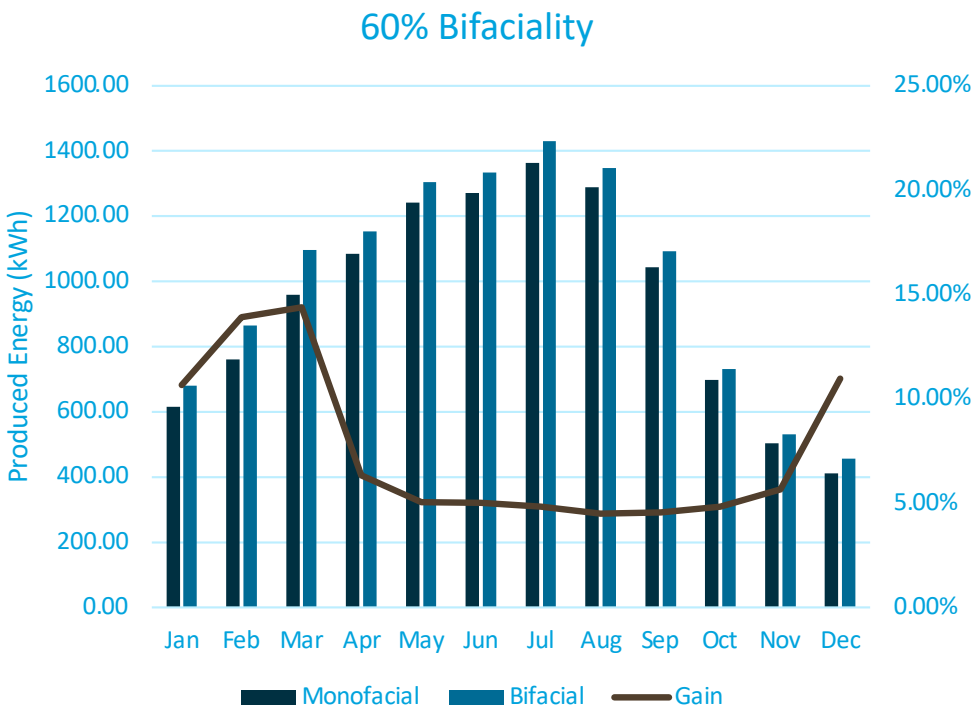

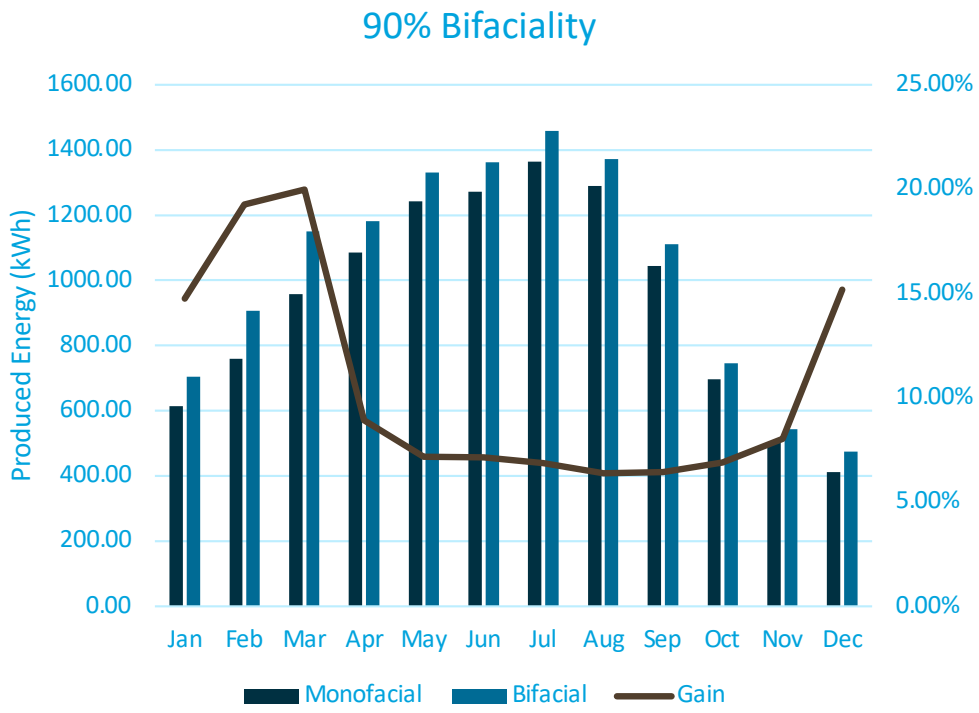

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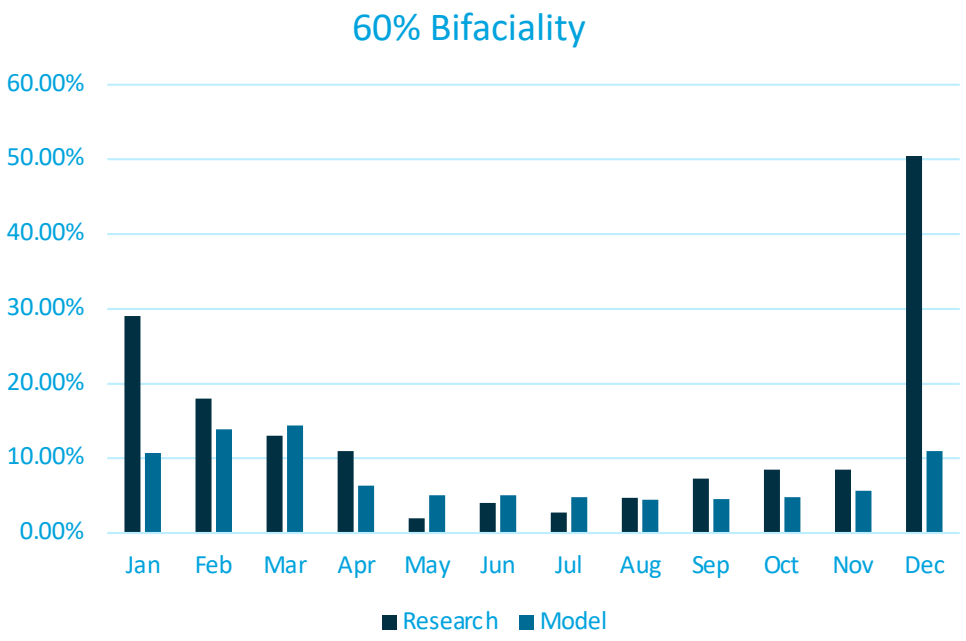

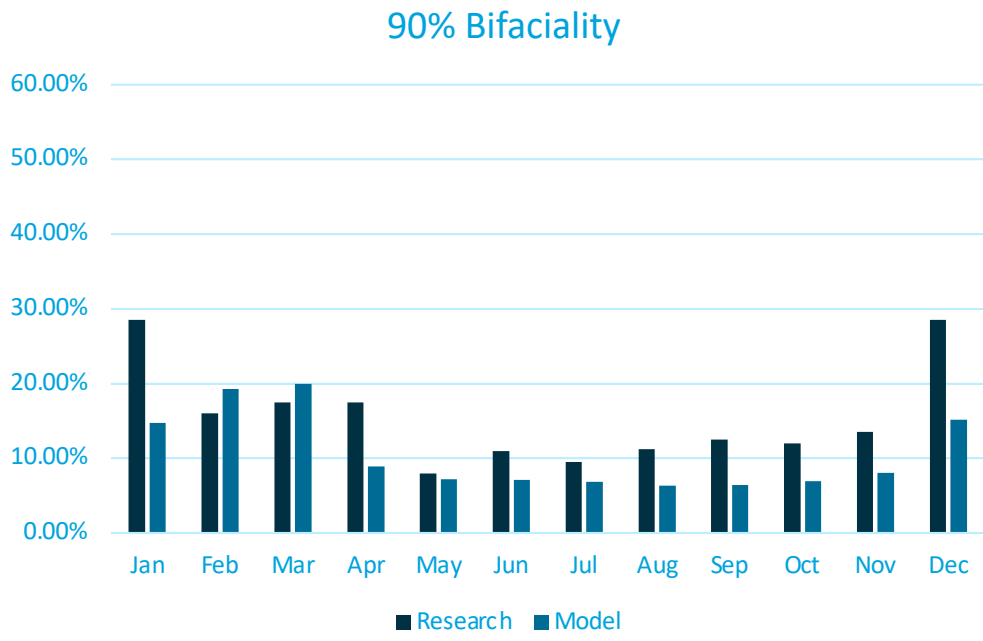

4. CONCLUSIONS

1. We have developed a method for bifacial modeling of photovoltaic systems with DAT, overcoming the limitations of PVSyst.

2. This method has been tested with a case study in a high-albedo environment, obtaining results that are consistent with empirical evidence.

3. We offer an approximation for bifacial modeling of this type of systems, and that it can be extrapolated to other types of bifacial systems.

4. We'd be happy to discuss further comments with all of you.

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