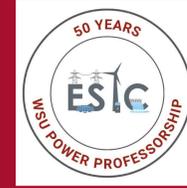




SUPPRESSING THE NET-LOAD DUCK-CURVE WITH EAST-WEST SOLAR ARRAY ORIENTATION

Sponsor: US-India CollAborative For Smart DiStribution System With Storage (UI-ASSIST)
Mentors: Dr. Noel Schulz, Dr. Sanjeev Pannala
Liadi Abiodun Akande



ABSTRACT

This poster compares the differences between East-West and South PV array orientations, and demonstrates how the East-West PV orientation is considerably beneficial in solving the evening ramp of the netload curve of the CAISO network. Simulations were done with Aurora Solar's Helioscope

INTRODUCTION

Duck curve phenomena happens when solar energy in higher amounts is injected into the grid. Massive solar energy system deployment is causing a specific and unwanted shape in the net demand, known as the "duck curve," which deepens during the peak solar PV injection hours at noon and quickly increases toward the evening.

As a result;

- Excess production cannot be delivered during solar peak hours, and some of the demand cannot be met when solar production is declining due to the inflexibility and low ramp rate of traditional generation plants.[1]
- One way to reduce the high ramp of the netload in the evening is to look at the orientation of the PV arrays.
- In The US, south-facing solar array is the best and would reduce costs the most on utility bills and have a shorter payback.[2]
- However, there is a pressing need to solve the risk of solar energy curtailment in the midday and grid network stability in the late afternoon ramp.

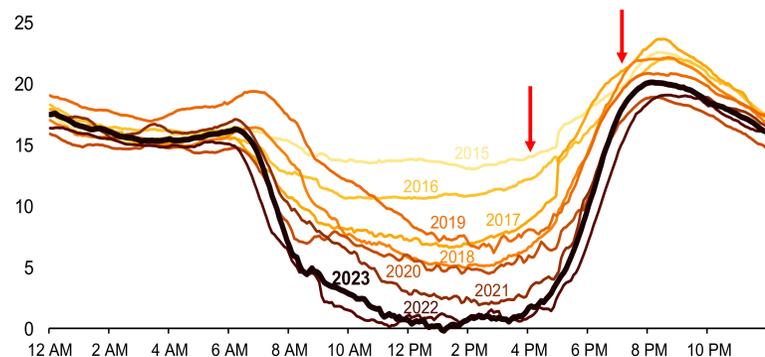


Figure 1: CAISO Duck Curve [1]

METHODOLOGY

- Using Helioscope, we simulated multiple scenario using a 100kWp PV array located in Sacramento California with coordinates of 38° 34' 51.82" N, 121° 29' 38.02" W. [2]
- First Simulation:** 100kWp southward with a tilt of 31°.
- Second Simulation:** 50kWp eastward & 50kWp westward.
- South oriented solar array's PV curve tends to have a steep ramp up in the morning and steep ramp down late in the evening, and a high peak in the midday.
- East-west oriented solar array's PV curve is more evenly distributed throughout the day.
- With this, the east-west PV array produces more in the late evening when the net load is ramping up, hence reducing the slope.
- In east-west orientation, there would be no need for overpaneling and the DC/AC ratio came be kept at ≤ 1

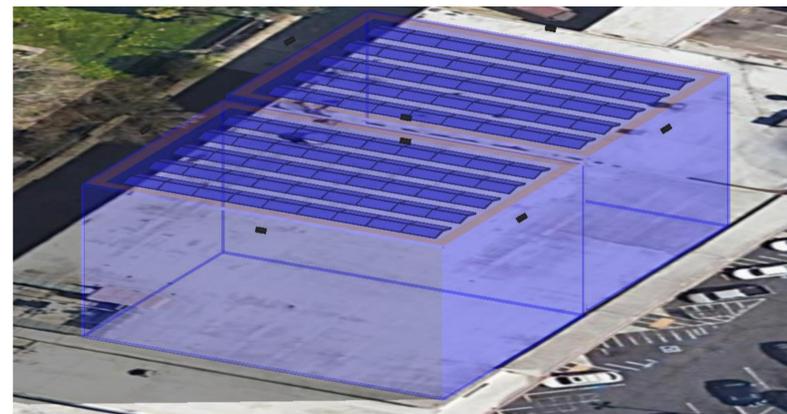


Figure 2: Solar East-West PV Array Orientation

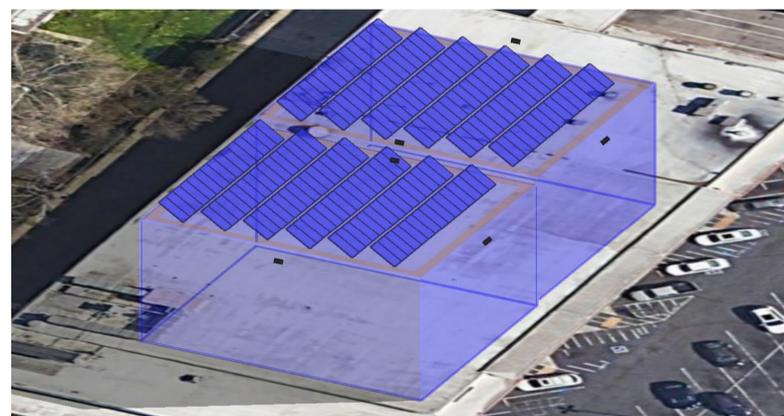


Figure 3: Solar South PV Array Orientation

RESULT

- Table 1 shows the differences in the output of the two orientations:
- The annual production of the south oriented array is higher than that of the east-west oriented array, but there is curtailment risk during the peak solar hour.

Table 1: Results Comparison for 100kWp Solar Installation

Parameter	East-West	South
Size (kWp)	100	100
Yield (MWh)	152.5	165.2
Performance Ratio	83.2%	78.9%
Shading Loss	0.2%	5.6%

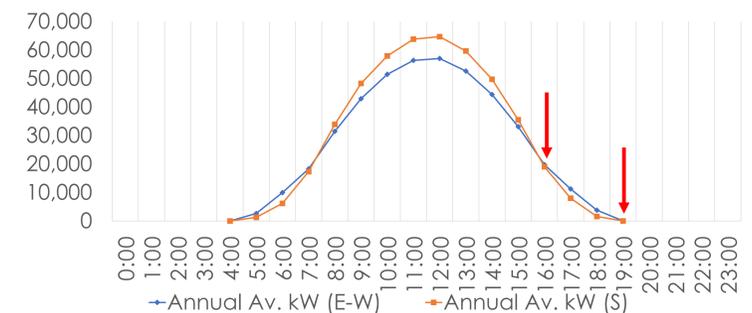


Figure 4: Solar PV Curve for 100kWp Solar Installation

- The total energy gained from 4PM to 8PM using east-west orientation rather than a south orientation is 2.13MWh per annum.
- There would be significant energy gain If the 100kWp system is scaled up to 100MWp.
- This could help in mitigating the evening ramp of the netload hence increasing system reliability.

Table 2: Evening Generations Comparison for 100kWp Solar Installation

Duration	E-W (MWh)	South (MWh)	Δ (MWh)
4PM-5PM	7.08	6.88	0.20
5PM-6PM	4.03	2.88	1.14
6PM-7PM	1.36	0.58	0.78
7PM-8PM	0.02	0.01	0.01
Total			2.13

SUMMARY

This work demonstrates that orientation of solar arrays can have a significant effect on the ramping up or down of available solar generation on the grid. In addition to the size of the solar installations, simulations are needed to see how array orientation on various locations might affect grid stability.

REFERENCES

- IEA, The California Duck Curve, IEA, Paris <https://www.iea.org/data-and-statistics/charts/the-california-duck-curve>, IEA.
- Solar Reviews (2022) What is the Best Direction for Solar arrays [Online]. Available: <https://www.solarreviews.com/blog/best-direction-orientation-solar-arrays>.

ACKNOWLEDGEMENT

This material is based upon work (partially) supported by the U.S. Department of Energy under Award Number DE-IA0000025. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.