Subhourly Clipping Correction Model Comparison

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Abstract

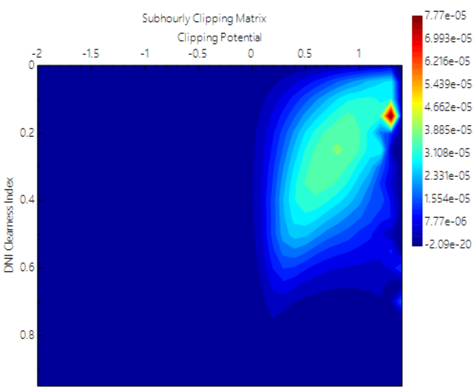
This work compares the Allen method and Walker method of accounting for subhourly inverter clipping power losses in hourly PV performance models. The Allen method uses a matrix lookup based on DNI clearness and clipping potential to assign a clipping correction loss at each simulation timestep. The Walker method models the PV DC power input to the inverter as a distribution over the hourly timestep and uses integration over the timestep to determine the amount of clipping that occurs within the timestep. Both these models have been recently implemented in the System Advisor Model's (SAM) open-source code and are applied to hourly SURFRAD datasets to analyze the subhourly clipping loss predicted by each model for different system designs and inverter loading conditions. Both models are compared to "true" 1-minute SURFRAD data simulations to see their accuracy against more accurate 1-minute clipping correction loss predictions. This model comparisons will be investigated in more detail in an oral presentation at the PVSC conference in Seattle, Washington June 2024.

Allen Method

- Allen method: Lookup matrix of clipping correction factors scaled with nominal annual energy output
- Matrix made through empirical methods, correlated with DNI clearness index and Clipping Potential:

$$\gamma_{DNI} = \frac{DNI}{DNI_{DryClean}}$$

$$CP = \frac{P_{dc,DryClean} - P_{ac,0}}{P_{ac,0}}$$



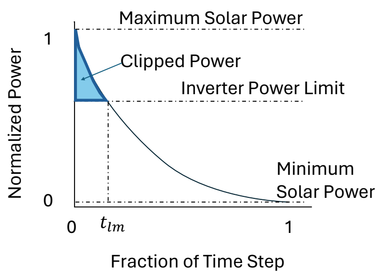
Walker Method

- Walker method: Models power output on distribution, integrates under inverter capacity to correct for power over capacity limit
- Models theoretical solar maximum based on clear-sky data, minimum based on atmospheric thickness and ratio of maximum
- Currently available through PySAM, HOMER ™ software

$$P_{solar} = P_{solar,min} + \left(P_{solar,max} - P_{solar,min}\right) * \left(1 - \left(\frac{t}{T}\right)^{\frac{CF}{CF-1}}\right)$$

$$CF = \frac{P_{solar} - P_{solar,min}}{P_{solar,max} - P_{solar,min}}$$

$$t_{lm} = Te^{\left[\frac{\ln\left(1 - \frac{L - P_{solar,min}}{P_{solar,max} - P_{solar,min}}\right)}{\frac{CF}{CF-1}}\right]}$$



Methodology

- Use System Advisor Model (SAM) and PySAM (Python wrapper for SAM source code) to calculate subhourly clipping loss for hourly SURFRAD resource data
- Compare results to "true" results calculated from 1-minute SURFRAD Data
- Sweep across inverter loading ratios (ILR), different resource locations from SURFRAD, other data resources
- Investigate trends in model behavior in annual energy, clipping loss results

Conclusions / Discussion

- **Both models accurate to within 4% of 1-minute results at high ILR**
- **Large improvement over typical hourly clipping**
- **Different modeling approaches results primarily in different curve shapes**

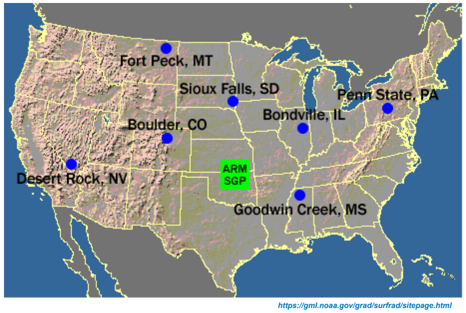
- **How do you account for subhourly clipping in hourly PV performance models?**
- **Are there other modeling approaches you would like to see in SAM or other software tools?**

Subhourly Clipping Loss Correction Modeling in SAM

Clipping Loss Results for different models in Desert Rock, NV normalized to pre-clipping annual energy output

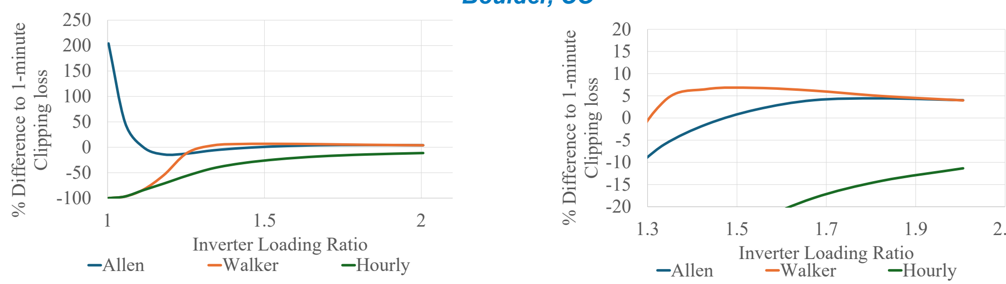
ILR	Hourly	Allen	Walker	1-Minute
1	0.00%	0.04%	0.00%	0.01%
1.10	0.01%	0.10%	0.01%	0.07%
1.19	0.37%	0.64%	0.46%	0.61%
1.29	2.00%	2.59%	2.54%	2.44%
1.39	4.69%	5.65%	5.73%	5.28%
1.49	7.85%	9.20%	9.25%	8.58%
1.58	11.23%	12.91%	12.88%	12.04%
1.68	14.63%	16.58%	16.44%	15.50%
1.78	18.00%	20.13%	19.92%	18.94%
1.88	21.28%	23.53%	23.28%	22.29%
1.97	24.44%	26.75%	26.49%	25.49%
2.00	25.26%	27.57%	27.32%	26.31%

SURFRAD Sites being analyzed in model comparisons

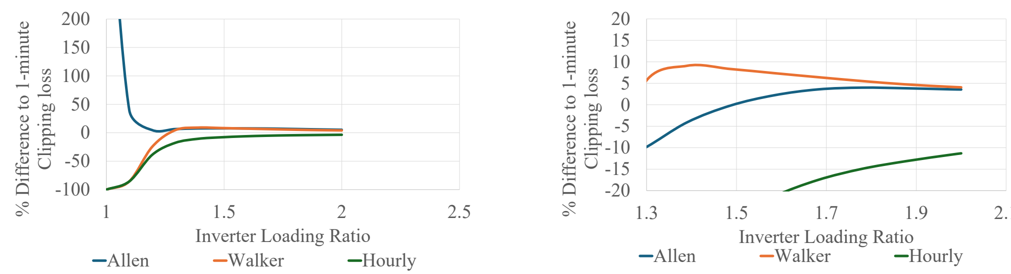


https://gml.noaa.gov/grad/surfrad/sitepage.html

Boulder, CO



Desert Rock, NV



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