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Estimating subhourly clipping from hourly data: a simplified approach

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Motivation

- Solar production is generally modeled at hourly resolution.
- Arrays often produces an amount of energy that exceeds the grid's injection capacity during some window within an hour, but this is hidden within hourly averages when the average still falls below the grid-clipping threshold.
- Subhourly losses can be significant (~1-4%).
- Several investigations have provided a framework for predicting subhourly losses, but they usually involve multi-step, time-consuming processes such as training machine-learning algorithms.
- This work seeks to develop a simplified method that developers can use to improve resource estimates at any project stage, leveraging Avangrid's minute-scale onsite data to create a basis for quickly estimating clipping loss present in a typical year (TMY).

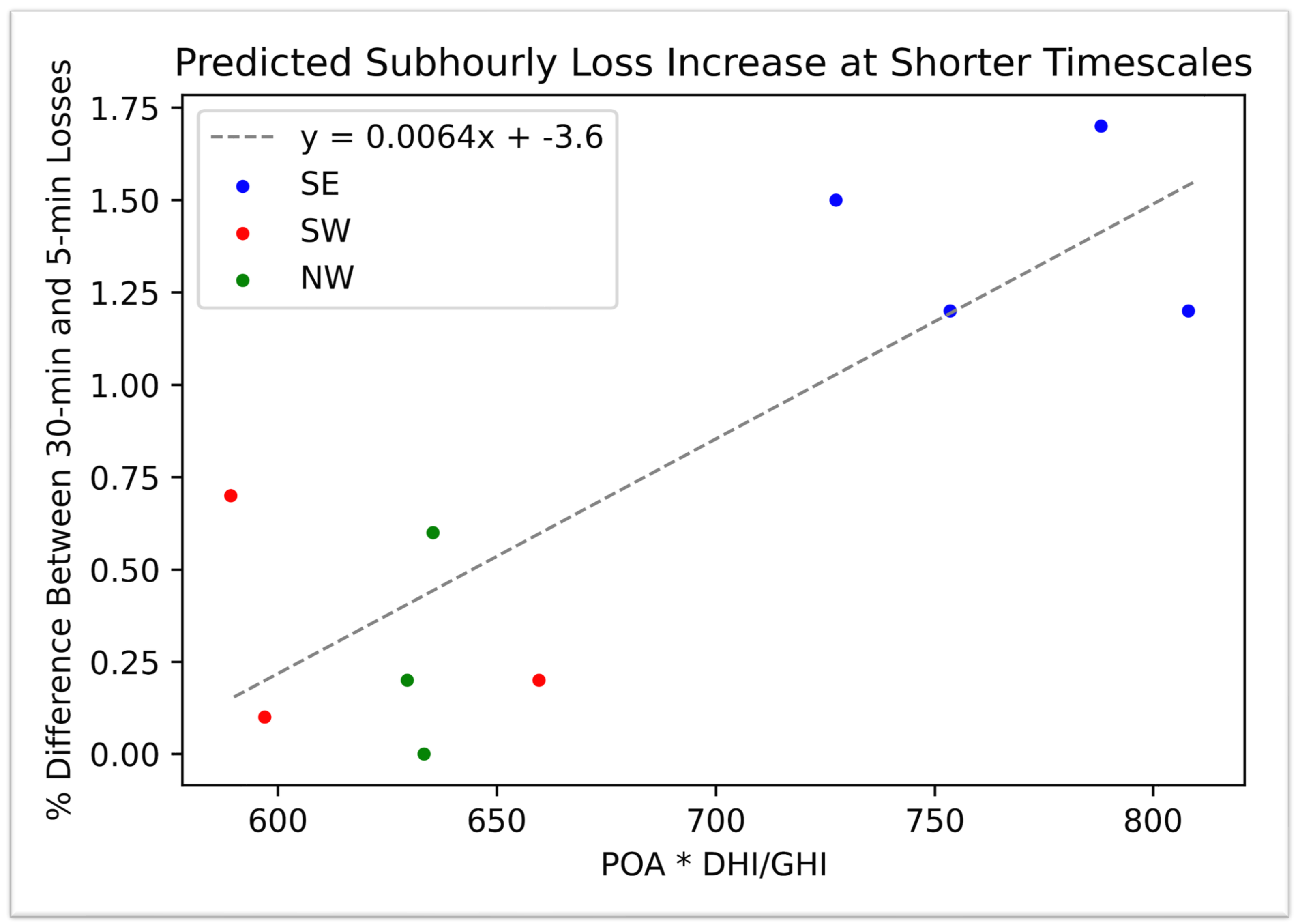
Setup

- Avangrid collects onsite irradiance data for one year, in one-minute increments. Because our quality control process begins after averaging data to five-minute intervals, this analysis uses timescales of five minutes and larger.
- We selected ten sites representing a range of environments/climates, and ran hourly onsite data through our standard modeling process in PVsyst. Using POA values obtained from the hourly production run, combined with a correlation process, we predicted subhourly losses in 5-30minute intervals.
- The parameter space for this project needed constraints, as any number of fundamental solar plant variables could be used in a regression. Anderson & Perry's 2020 work[1] demonstrates that clearsky POA irradiance was the strongest predictor of clipping loss, with variables like cell temperature and GHI trailing behind. We examined various combinations of these to see whether an empirical equation could be reasonably applied to any site.

Analysis

- All sites but one (northern Oregon) exhibit a meaningful increase in the clipping error as the timescale shortens, which is in step with other results (Cormode et al[2], for example). This may be a side effect of the water-body dependence identified in NREL's study[1], as the site is near a waterbody large enough to create its own microclimate.
- Since curve-fitting the production as a function of POA has some error associated with it, it may be appropriate to use the 30-minute data as a base case to which we can compare results from other timescales. The difference between production achieved at 5-minute and 30-minute intervals is plotted against the DHI:GHI ratio of the site, normalized by the site POA (below).
- To simplify our process as much as possible, no nonlinear fits were explored.
- All three regions perform as expected when compared to past work, with desert climates experiencing the lowest loss. More of our sites in the Rocky Mountains and New England will be added to this analysis as deployments complete.

Site #	Region	State	30min Loss (Baseline)	10min Loss	5min Loss	30-5min Difference	DHI:GHI	POA kWh/m²
1	SE	KY	0.3%	1.4%	1.8%	1.5%	37%	1966
2	SE	TN	0.3%	1.0%	1.5%	1.2%	39%	808
3	SE	GA	5.3%	6.3%	7.0%	1.7%	36%	788
4	SE	TX	0.1%	0.6%	6.1%	1.2%	21%	2093
5	SW	AZ	0.1%	0.6%	0.8%	0.7%	21%	2806
6	SW	CA	10.1%	10.1%	10.2%	0.1%	20%	2985
7	SW	NV	5.4%	5.4%	5.6%	0.2%	26%	2537
8	NW	OR-S	0.4%	0.8%	1.0%	0.6%	26%	2444
9	NW	OR-N	0.8%	0.8%	0.8%	<0.1%	29%	2184
10	NW	WA	5.0%	5.2%	5.2%	0.2%	31%	2031



Above:
Plot of the change in subhourly losses with shorter timescales, predicted by a simple combination of variables (the normalized DHI:GHI ratio).
Left:
Locations analyzed for this project and their respective subhourly losses. Sites were selected based on deployment length, data quality, and equipment similarities.

Conclusions & Future Work

- While no analysis with just ten data points is definitive, a simple linear fit using a normalized DHI:GHI ratio shows promise for further exploration.
- Other variables, when applied on an annual timescale, did not show strong correlations but could be re-explored with the addition of more data.
- Data availability may have a small impact on the results. Some deployments were impacted by forest fires in 2020.
- Operational data may be leveraged in the future to further explore subhourly modeling.

References
1. *Anderson, K, & Perry, K (2020). Estimating Subhourly Inverter Clipping Loss From Satellite-Derived Irradiance Data. 2020 47th IEEE Photovoltaic Specialists ..., ieeexplore.ieee.org, https://ieeexplore.ieee.org/abstract/document/9300750/*
2. *D. Cormode, N. Croft, R. Hamilton and S. Kottmer, "A method for error compensation of modeled annual energy production estimates introduced by intra-hour irradiance variability at PV power plants with a high DC to AC ratio," 2019 IEEE 46th Photovoltaic Specialists Conference (PVSC), 2019, pp. 2293-2298, doi: 10.1109/PVSC40753.2019.8981206.*