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Using Measured Plane-of-Array Data Directly in Photovoltaic Modeling: Methodology and Validation

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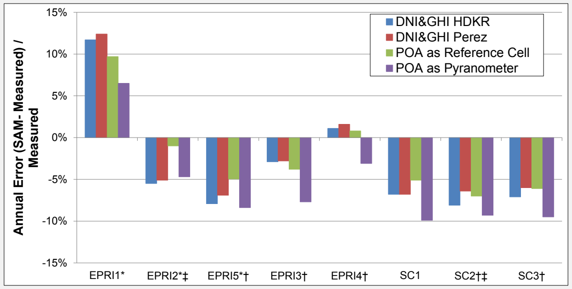
Abstract

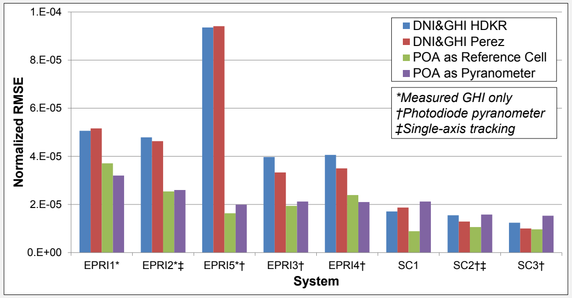
Measured plane-of-array (POA) irradiance data may provide a lower-cost alternative to standard irradiance component data for PV system performance modeling without loss of accuracy.

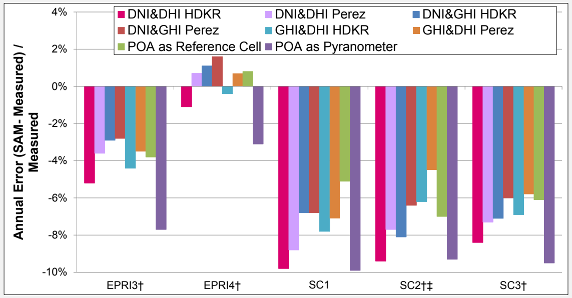
Previous work has shown that transposition models typically used by PV models to calculate POA irradiance from horizontal data introduce error into the POA irradiance estimates [1]-[4], and that measured POA data can correlate better to measured performance data [5]-[6]. However, popular PV modeling tools historically have not directly used input POA data. This work introduces a new capability in NREL's System Advisor Model (SAM) to directly use POA data in PV modeling, and compares SAM results from both POA irradiance and irradiance components inputs against measured performance data for eight operating PV systems.

Study Results

- RMSE is improved using measured POA data compared to traditional irradiance input methods:
  - Always- when treating POA as a reference cell
  - Usually- when treating POA as a pyranometer
- Even though POA data is always measured with pyranometer, treating it as a reference cell frequently provides better results both for RMSE and annual error than treating it as a pyranometer
- Both POA methods perform within same range of error as transposition model options, although POA treated as a reference cell is frequently more consistent with traditional methods
- Uncertainty in loss assumptions and data quality control make annual error comparisons instructive, but **not** indicative of absolute accuracy



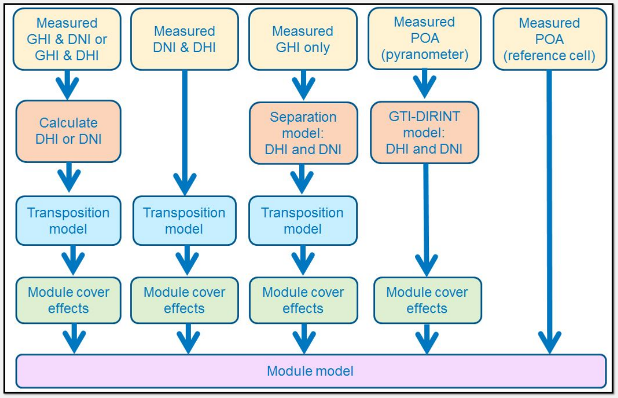




Left: Normalized root mean square error after annual energy prediction is adjusted to match measured annual energy, Top: Annual error, Bottom: Annual error for systems with additional measured data

Model Implementation

Models Required for Different Input Irradiance Options



Two new POA input options are available in SAM:

- "POA Pyranometer" uses a POA decomposition model to apply module cover losses to the beam portion of the irradiance
- "POA Reference Cell" option assumes module cover effects are already accounted for in the data and does not apply any module cover losses

Some models still require beam and diffuse components of the POA, and will trigger the decomposition model:

- All types of shading
- Concentrating PV (using a diffuse utilization factor)
- "Heat transfer" module temperature model

Conclusions and Future Work

POA Irradiance Data Provides Similar Accuracy

The two POA model options in SAM perform comparably to conventional input methods for eight systems. The RMSE is improved for most systems by using the POA input options, and the annual error falls within the same range as the traditional methods. Using POA irradiance data directly may help developers achieve a balance between cost and accuracy when measuring irradiance data for PV performance modeling.

Improve Understanding of Cover Effects

Treating the POA pyranometer data as a reference cell sometimes results in better RMSE than treating it as a pyranometer. This indicates that we need to better understand cover effects for both POA sensors and modules themselves. Module cover losses may be smaller or more constant than they are generally assumed to be, or pyranometer cover effects may be more significant than we realize.

Reduce Uncertainty in Loss Assumptions

Uncertainty and error in input loss assumptions makes it impossible to determine which method most accurately models a system. We need to improve loss modeling for PV modeling in general, so that we can better identify differences between modeling options.

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