Recommendations and limitations for winter PV capacity tests

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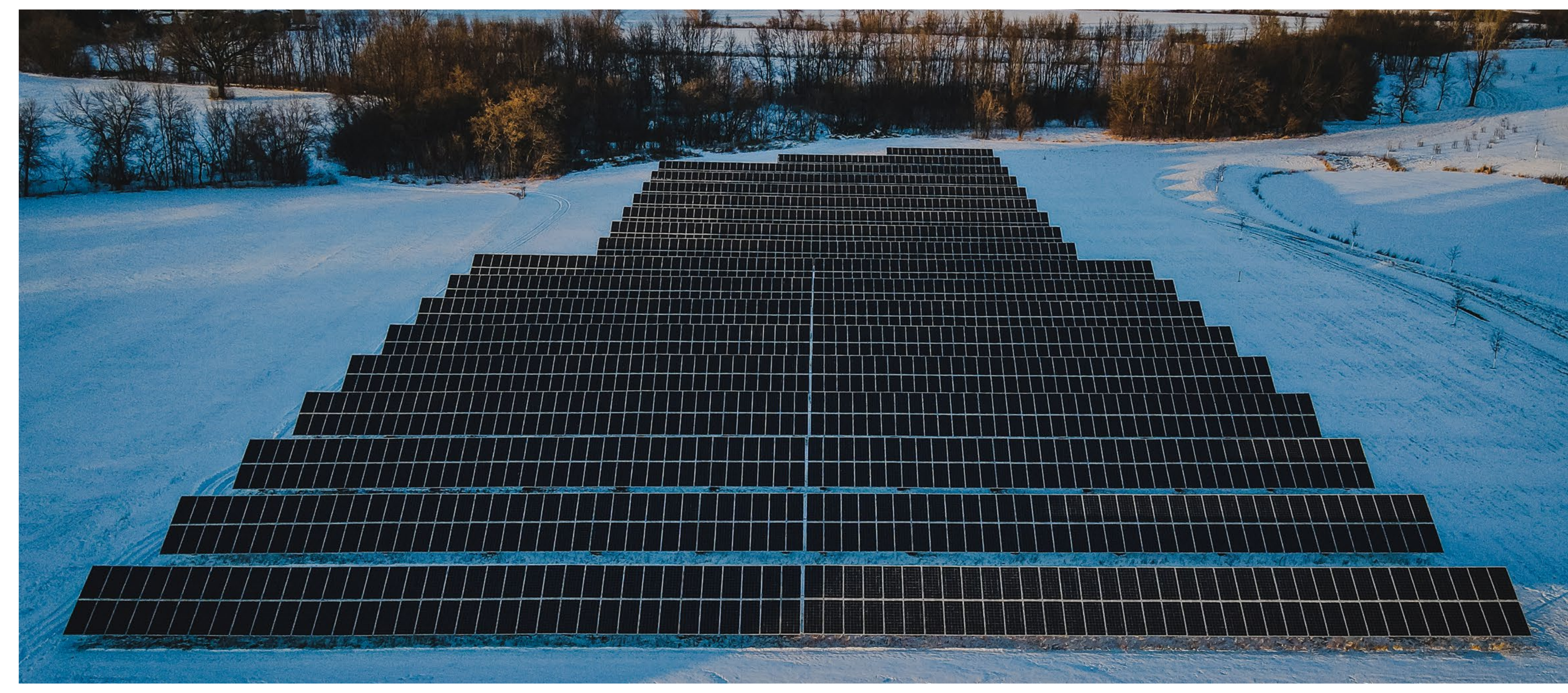
Introduction

Capacity testing is a critical acceptance procedure for photovoltaic (PV) projects, often required for key completion milestones. However, common testing methods, which rely on regression analysis of stable and linear data, can be hindered by challenging weather conditions in the winter and complex system designs. This makes it difficult to obtain sufficient valid data within the required timeframe. Various strategies are employed to address these challenges, ensuring that accurate results are still achievable. This study will explore different strategies and limitations to overcome weather-related restrictions in capacity testing, highlighting methods to ensure reliable results despite environmental constraints.



Overview

ASTM E2848 provides a standardized approach for verifying PV system performance through a linear regression of power against plane-of-array (POA) irradiance. However, during winter, increased shading, low irradiance, and variable weather conditions can limit data availability, potentially preventing systems from meeting ASTM E2848 requirements. This study explores key considerations for conducting reliable winter PV capacity tests while ensuring that adjustments do not introduce additional uncertainty, particularly for crystalline silicon modules.

Common ASTM E2848 winter adjustments

1. Period of Record Extension:

Method: The ASTM standard 4-week rolling window for recording data. Continue a 4-week rolling window to capture adequate datapoints, if possible.

Limitation: May not always be feasible from a commercial standpoint.

Advantage: Maintains the ASTM recommendations.

2. Using Shorter Time Intervals

Method: The ASTM standard recommends at least 750 minutes of data points post-filtering which means 50 data points for a 15-minute data recording interval, 150 datapoints at a five-minute interval, or 750 minutes at a 1-minute interval. Using a shorter time interval can increase the available datapoints for the test method.

Limitation: At lower time intervals module temperature may lag behind the irradiance values impacting the power output vs irradiance; however, this error should be minimized by the behavior over the course of the day.

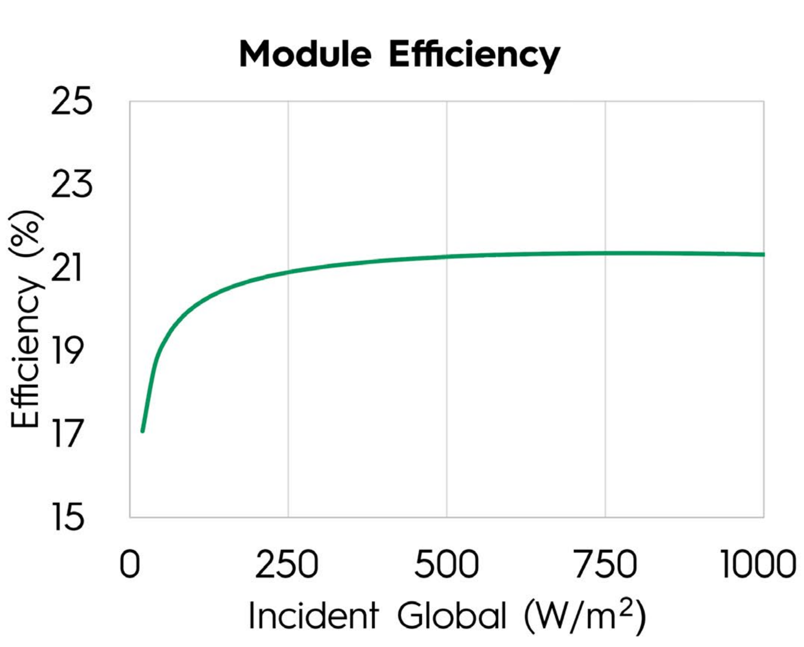
Advantage: Maintains the ASTM recommendations.

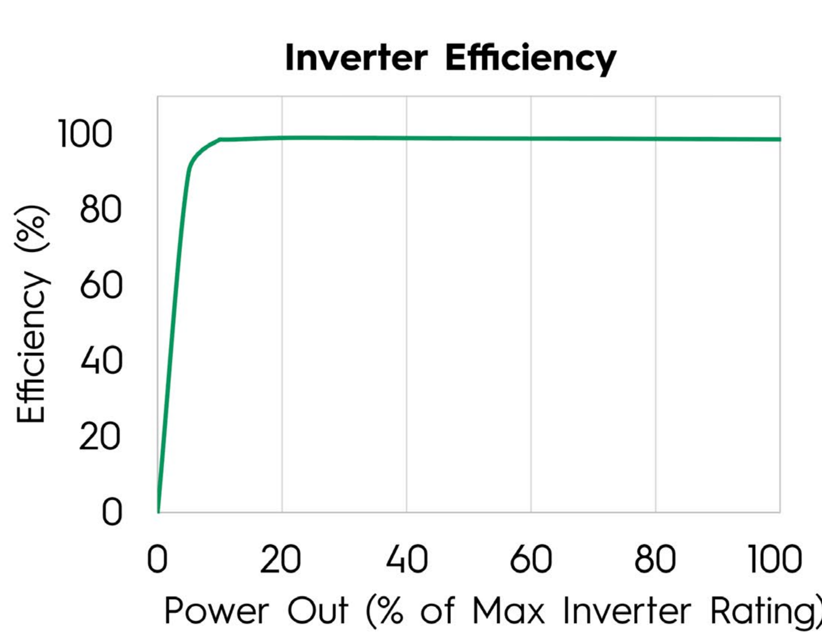
3. Using Lower Irradiance Values (<400 W/m2):

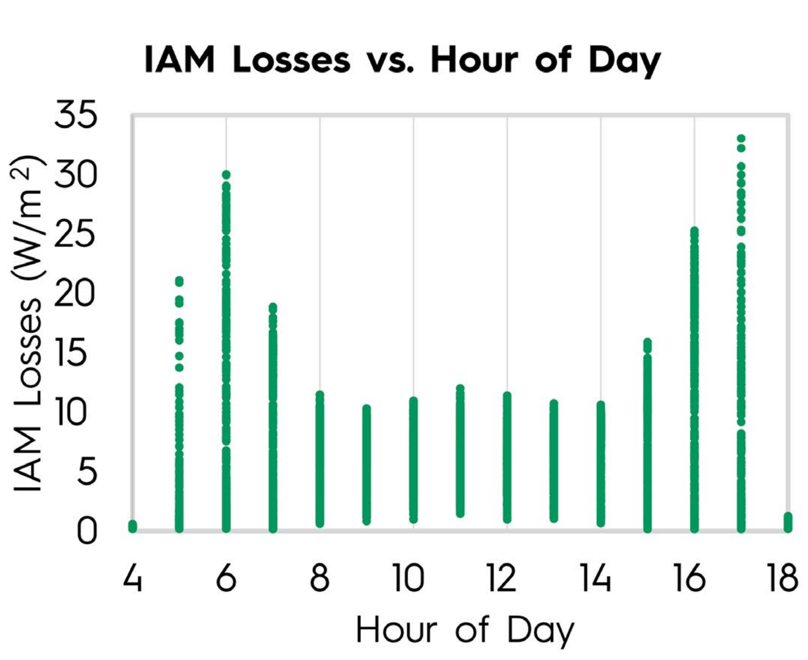
Method: Reduce the lower irradiance limit to 250-300 W/m2. Evaluate at an irradiance reporting condition within the measured data.

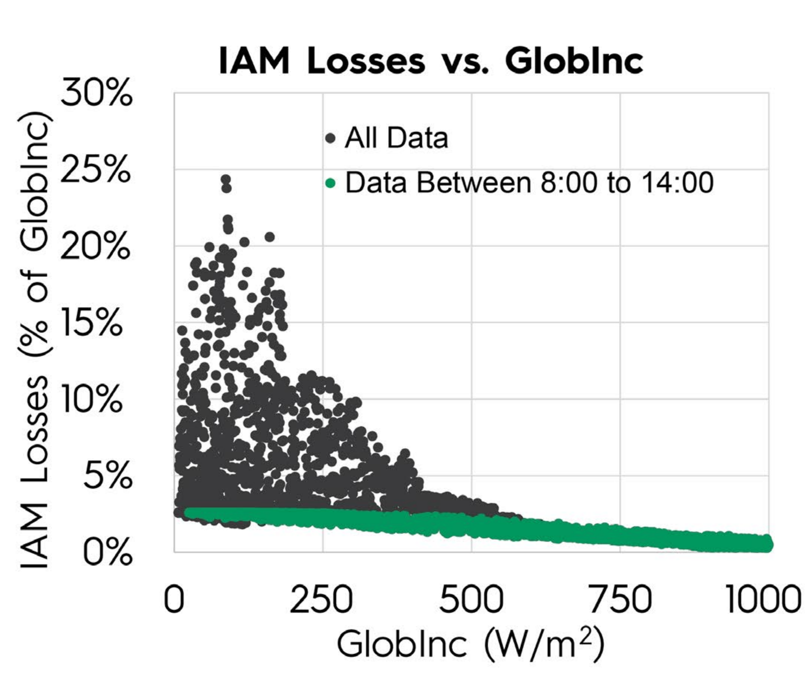
Limitation: Linearity assumptions may not hold at low irradiances due to inverter and module efficiencies, as well as IAM losses at lower irradiance values.

Advantage/Recommendations: Allows for the recommended data points per ASTM E2848 to be captured. Restrict the boundaries around the reporting conditions and evaluate the R2 value to confirm linearity. In order to reduce risk of error due to IAM non-linearity consider reviewing the site-specific energy model to understand times where high IAM losses will be and restrict their use in the regression.









4. Fixing Trackers to a Fixed Tilt Position:

Method: In the event that trackers have significant inter row shading, or there are limited times where clipping does not occur. Trackers may be stowed at a fixed tilt position to achieve the required data points per the ASTM standard.

Limitation: This method does not capture the tracker performance.

Advantage/Recommendation: Allows for the recommended data points per ASTM E2848 to be captured. As this method does not evaluate tracker performance, review commissioning data for trackers. If accuracy of trackers is a concern, consider performing analysis on the tilt accuracy.

5. Inclusion of Data with Shading (up to 3%):

Method: Include timestamps where shading may occur up to 3% per the energy model.

Limitation: Non-linearities in the data may be present, impacting the uncertainty.

Advantage/Recommendation: Allows for the recommended data points per ASTM E2848 to be captured. Ensure time of day is considered in the modelled data to prevent inclusion of modelled data with shading greater than 3% (as modelled data is typically hourly).

6. Push Capacity Testing to Final Completion:

Method: When a capacity test cannot be completed with any modifications that maintain the statistical significance of the test it may be necessary to move the test to Final Completion.

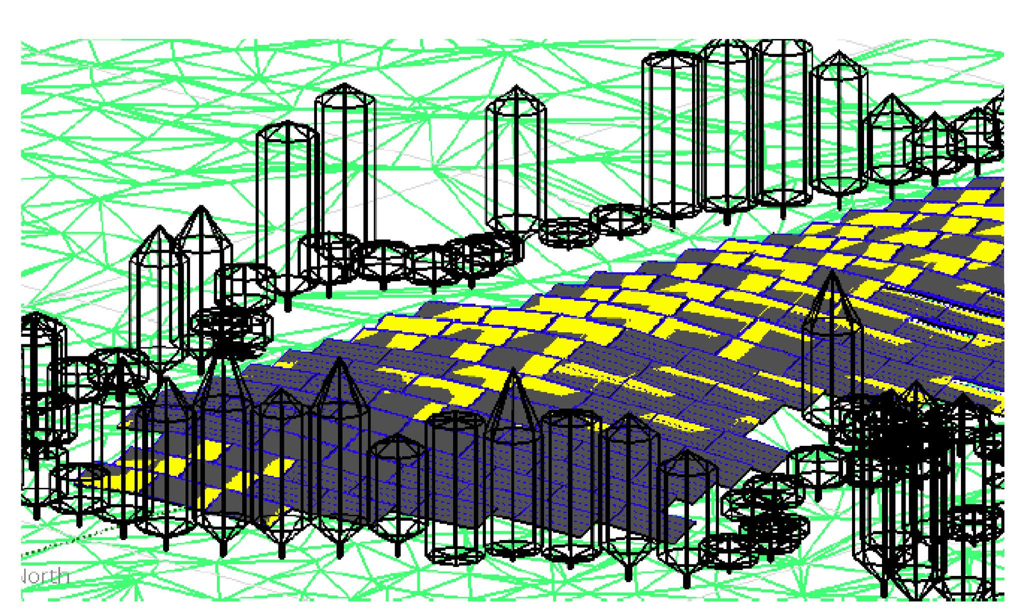
Limitation: The capacity test is usually used to confirm if construction was adequately performed, or that the site is capable of producing its expected energy per the energy model for a financial funding. The inability to pass a capacity test increases the risk for the stakeholder.

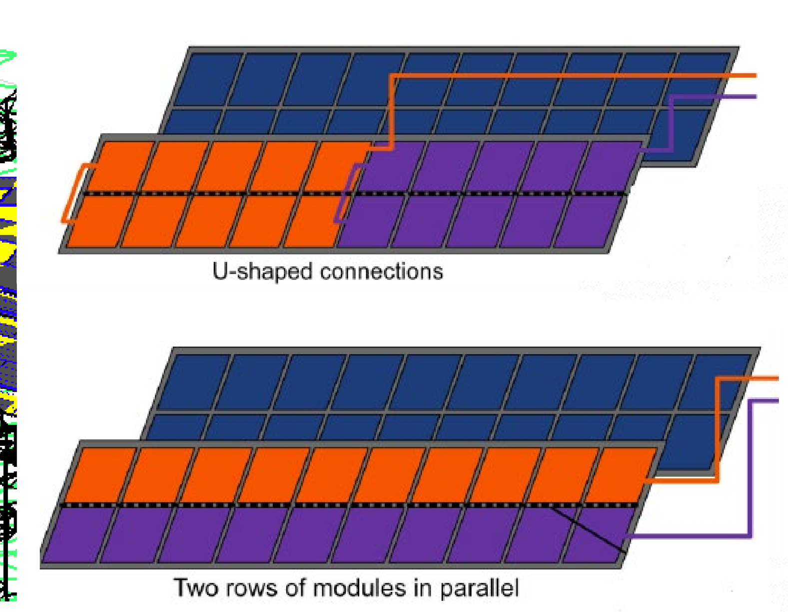
Advantage/Recommendation: Prevents the need for modifications to the ASTM standard. Ensure there is financial holdback from the engineering, procurement and construction agreement to incentivize the sufficient completion of the test, complete an interim capacity test to confirm the time of year is the reason the test cannot be completed, and review additional commissioning testing to evaluate if there are any issues that need to be remedied.

General recommendations

Ensure the energy model (PVSyst) considers the as-built conditions including:

- **Near shading objects:** Use tree surveys or timestamped aerial imagery to verify shading impacts. Ensure all obstructions (buildings, poles, trees, etc.) are correctly modeled to prevent underestimated shading losses.
- **Ground undulation:** Confirm that the energy model accounts for site topography. Uneven terrain can impact row-to-row shading, especially in tracking systems.
- **String configuration:** Incorporate the actual stringing layout in the energy model. Verify string configuration via site visits or photographs to prevent inaccuracy in electrical shading assumptions.
- **POA placement and modeling adjustments:** Ensure POA sensors are in unshaded locations year-round. If shading is unavoidable at certain times, place additional POA sensors in areas with minimal shading variations.
  - If sensors are in highly shaded areas, adjust the modelled POA data to align with actual site conditions. Simulate POA sensor locations in PVSyst and compare them with measured data. For example, GlobInc in PVSyst is commonly used in performance testing but does not account for diffuse or beam shading. Ensure this is factored into comparisons between modeled and measured data and consider modelling the POA sensor location in modelling software for comparison with the measured data.





Conclusion

Winter capacity testing presents challenges due to low irradiance, increased shading, snow accumulation, and variable weather conditions, all of which can temporarily reduce power output and impact compliance with ASTM E2848 requirements. Shorter daylight hours and lower sun angles further limit the testing window, while seasonal shading from trees, buildings, or terrain may introduce inconsistencies. If standard conditions cannot be met, alternative test scheduling or supplementary validation methods such as extending the testing period, lowering the irradiance threshold, or including minimal shading periods can help capture more data points. However, any modifications beyond ASTM E2848 should be carefully evaluated to avoid increased uncertainty in performance results. Lastly, ensuring accurate site-specific modeling in PVSyst and ensuring the model reflects site conditions, can enhance the reliability of winter test assessments.

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