CHALLENGES OF PV SYSTEM ACCEPTANCE TESTING IN WINTER

CHRISTINE BORDONARO, PHD. PRINCIPAL ENGINEER

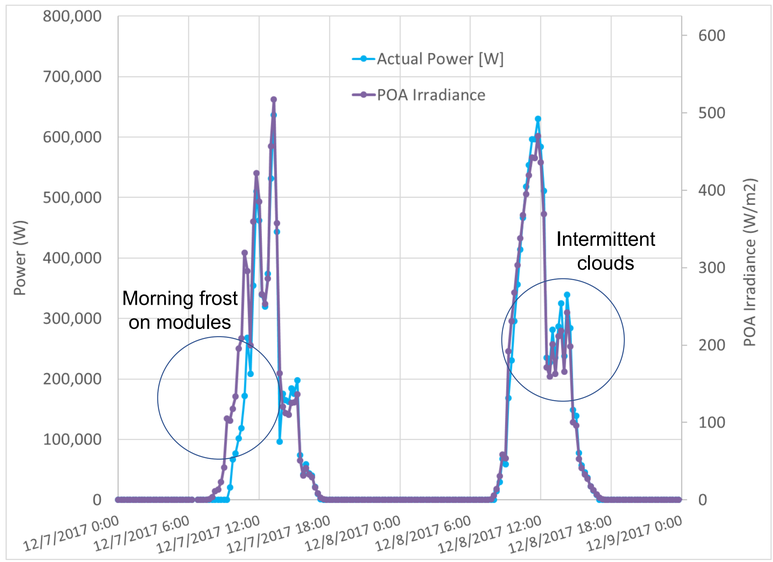
ABSTRACT

PV plant commissioning is often completed in the winter months due to unplanned delays in the construction schedule. For systems in the northern U. S., this results in final acceptance testing being conducted under the most difficult of weather conditions: low irradiance (most test standards eliminate data below at least 200 W/m^2 and irradiance may only reach 500 W/m^2 in the winter months), intermittent clouds, and sometimes snow. For a system developer, owner, or financer, understanding the basic types of acceptance tests and their limitations is critical in establishing practical plant acceptance criteria for this time of year.

PV plant acceptance tests typically range from 3 to 10 days, and are based on one of two main test types: Capacity-style tests or Performance-Ratio type tests. Capacity test procedures work by determining the "capacity", or output power, of the plant under a specified set of conditions and comparing this to an expected value. In contrast, a Performance Ratio test is based on total energy production over a specified period of time, which is then also compared to a benchmark value. In both cases, acceptance criteria are established which set minimum passing percentages of the actual over the expected values. While both test types have their limitations under difficult winter weather conditions, capacity style tests provide a better format for testing under these conditions for a variety of reasons which will be presented.

This poster provides an overview of both Capacity style tests and Performance-Ratio type tests; discusses caveats in using both test types, particularly for testing in winter weather conditions; presents case studies to demonstrate the differences between these two main test types; and provides acceptance test procedure guidelines for difficult winter weather conditions.

Sample data set, PV project in Northeast US (Project A)

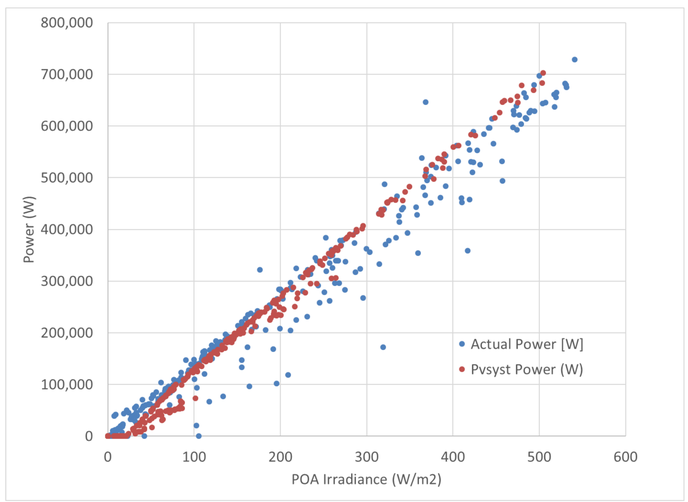


TYPES OF PV PLANT ACCEPTANCE TESTS

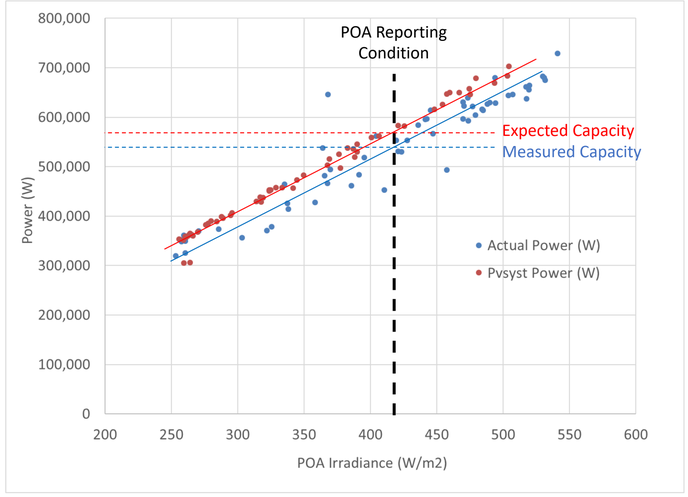
Capacity Test

- ASTM 2848 standard is typically followed in the US
- Basic premise: plant power is a multiple linear function of solar POA irradiance, ambient temperature and wind speed
- Standard recommends 12.5 hours of test data, after filtering

Acceptance data, Project (A)



- Unfiltered measured data compared to PVsyst datapoints from month of December
- Data is filtered to remove points creating scatter, such as low irradiance, unstable irradiance, shading, snow, etc. (see filtered plot below)



- Linear regressions on both the filtered test data and PVsyst data are computed
- "Reporting Conditions" are selected, typically median irradiance, wind speed and temperature
- "Measured Capacity" is the calculated power using the regression equation at the "Reporting Conditions"
- "Expected Capacity" is determined at these Reporting Conditions using the PVsyst model, and is compared to "Measured Capacity"

Capacity style test works very well in winter because we can filter out many of the "noisy" data points.

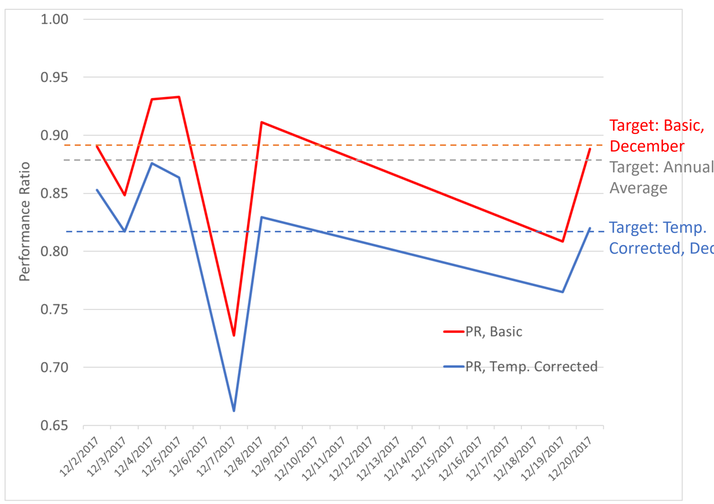
Performance Ratio (PR)

- Test standards and lengths vary, options include the basic PR calculation or following the NREL TP-5200-57991 weather corrected standard:

$$\text{PR, Basic} = \frac{\text{Yield (kWh/kWp)}}{\text{POA Irradiation (kWh/m}^2\text{)}} \qquad \text{PR, NREL} = \frac{\text{PR,Basic}}{(1 - \alpha^*(T_{cell,avg} - T_{cell,test}))}$$

where:
α = Module temp. coefficient (1/°C) (negative in sign)
Tcell, avg = Annual average cell temp. Tcell, test = Cell temp. during test interval

Acceptance data plotted as PR, Project (A)



- Potential targets for PR acceptance tests include:
  - Annual average PR
  - Monthly PR, Basic
  - Monthly PR, Temp. Corrected
- Which one is correct?
- Monthly Temp. Corrected target is often the same as Annual Average, but in this case due to winter shading, the model predicts quite a bit lower
- Monthly Temp. Corrected is most representative of performance and should be used

- Actual test data (above) shows significant fluctuation in PR depending on test day
  - Data is typically not filtered in PR tests so noise tends to be a problem when analyzing plant performance in this manner
- Test likely passes if Temp. Corrected PR for December used as target, but likely fails with other targets

Challenges with Performance Ratio acceptance tests in winter months

- Annual Average PR often used as test target, but both Basic and Temp. Corrected PR can vary quite a bit from the average depending on the season
  - Monthly temperature-corrected PR is most correct and should be used
- Not a preferred acceptance test for winter months because "noisy" data points are not excluded