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Corrections Needed For PV Performance Blind Spots During Commissioning

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James Mokri & Joseph Cunningham

If a photovoltaic system is commissioned according to industry standards, then it must be performing as expected, right? Not necessarily. PV industry standards for commissioning do not include performance testing.

NEC code and IEC 62446 mention nothing about performance testing. ASTM E2848-11 outlines a method of performance measurement during the commissioning stage, but it is not a complete, consistent, standardized method of measurement and metrics.

As a continuation of the PV Performance Metrics study performed by SunSpec and SolarTech members, along with San Jose State University (see "**Improved Performance Assessment Leads To Greater PV Plant Bankability**," ***SI,*** April 2014), we have recruited a group of industry professionals with a variety of experience and expertise to publish a guide containing performance verification steps during the commissioning of any PV plant. This group is led by Paul Hernday, senior applications engineer at Solmetric.

Commissioning to keep promises

Why is performance measurement an important component of the commissioning process? Ask any system owner, financial partner or operations and maintenance (O&M) provider what the key metrics are for any system. They all include actual kWh production versus expectations directly related to dollars produced by the PV system.

The SunSpec performance committee received the message from industry professionals, investors and PV system owners that PV performance must be included in the commissioning stages of a project. This was confirmed in surveys we performed in December 2012 and July 2013. The industry needs a consistent, standardized method for verifying system design, installation and function, performance measurement, data collection, and the metrics used during the commissioning of a PV project to affirm that the energy output of the system meets or exceeds expectations, and that it may continue to do so for the life of the system.

Proper commissioning is the final step in the investment due diligence process through which an investor realizes that the PV system investment, as represented prior to construction, actually will produce the amount of energy, and hence the dollars and return on investment - as promised - and that it should continue to do so for at least the life of the investment, as long as it is properly maintained. If the commissioning process does not return a favorable report in all aspects, including system performance, then why should the investment be finalized? Consider a housing development investment: If you agree

to invest in a 100-unit apartment complex, but the property has only 90 units after construction, the whole basis of the investment is altered.

In business parlance, commissioning is a process by which an equipment, facility or plant that is installed, complete or near completion is tested to verify if it functions according to its design objectives or specifications. According to the electric power industry, power plant commissioning is the process of assuring that all systems and components of a power plant are designed, installed, tested, operated and maintained according to the operational requirements of the client. The key words in these definitions are "functions according to design objectives" and "according to the operational requirements of the client."

Owners, financial institutions or any guarantor of system production should not accept a commissioning process that does not include tests to verify that it functions according to the original design objectives (including predicted energy production) that were used as a basis for the investment decision. Furthermore, these tests must be standardized and consistent during the commissioning of all PV projects. These steps will help remove some of the risk associated with the revenue expectations of a PV plant investment.

Such risk is defined in Fitch Ratings' Rating Criteria for Solar Power Projects, published last year, as one of the key elements of the total risk assessment for any PV plant investment. Simply put, anyone with a financial interest in a PV project wants to know prior to acceptance of the system, "Am I getting the PV energy production at the time of commissioning, which was promised when I made my investment decision?"

If you agree to invest in a 100-unit apartment complex, but the property has only 90 units after construction, the whole basis of the investment is altered.

Real-world need

As a group, we have run across several cases where service calls revealed issues that should have been identified in the commissioning process.

In one case, a commercial rooftop plant was commissioned by the installing contractor and a representative from a well-respected inverter manufacturer. All systems were reported to be working well. However, monitoring data a few months later indicated that part of the system was producing far less energy than expected.

After much troubleshooting, it was discovered that the maximum power point tracking software settings of the inverter were not configured properly, and the kWh production of the system was about 25% lower than it should have been. The settings were changed remotely in five minutes, and system performance immediately improved by 30%.

However, months of valuable kWh production were lost because this was not noticed during commissioning when the contractor took for granted that the inverter commissioning process was adequate. A simple test to verify PV system output against the expected output at the time of commissioning would have revealed the problem immediately.

In another instance, a 30 kW PV system was installed on parking/shade structures in Phoenix. Commissioning consisted mainly of a final check of the main connections, turning the inverters on, and waiting to see that all items were working correctly and that the system was producing power. The power produced at that time appeared to be adequate. A few months later, the customer complained of lower than expected savings on his utility bill.

A review of the monitoring data confirmed that the kWh production had dropped significantly - but gradually - within the first few weeks of operation. A field inspection revealed a reversed ground polarity of some of the strings. The wiring was redone, correctly, and the system returned to normal power production within days.

An adequate commissioning procedure should have revealed the reversed polarity of the grounding elements. Even if the polarity issue was missed, a more thorough performance test during commissioning, including the capture of performance data for more than one day,

would have caught the power reduction within days after installation.

Inside the guide

The SunSpec team of PV industry professionals is working on a set of guidelines that address the PV plant as a whole system during commissioning to verify that it is performing as expected, and that it will continue to do so, provided it is properly maintained. This is intended to be a supplementary guide to existing or developing industry standards with an emphasis on PV production performance measurement and verification during commissioning. It is not meant to be a set of standards or to replace any existing standards.

This guide is intended to be used by solar sector professionals - developers; engineering, procurement and construction firms; PV system owners; financial institutions; and O&M providers - as the basis for developing a consistent, standardized method of performance verification and measurement during commissioning, as well as the metrics used to record and report commissioning test results. There is further discussion in the guide on how to use the results to help satisfy one's risk assessment, or for future O&M purposes.

The guide will address the following:

- The business case for performance testing during commissioning that includes a full year of performance data and a recommendation for a secondary commissioning process to account for hidden defects that often become manifest after a "break-in" period of six to 12 months;
- Recommendations for performance metrics during the initial commissioning, as well as for the secondary commissioning, along with methods of measurement, data collection and metrics reporting;
- Actual performance metrics to be used and methods of measurement and data collection, including the summary of an 18-month study performed by this team and San Jose State University;
- I-V curve tracing and array performance, including its relationship to PV system performance and methods of measurement and application;
- Methods of irradiance measurement, including uncertainties associated with each method and recommendations on how to best measure irradiance;
- Methods of cell temperature measurement, including uncertainties associated with each method and recommendations of how to best measure cell temperature;
- Insulation resistance as it relates to PV system performance; and
- Infrared measurements as they relate to PV system performance.

By employing these guidelines, we believe that any financially interested party will be more secure in the knowledge that the risk of revenue generation has been mitigated from the time the system first starts producing income through the generation of electric power, throughout the life of the investment. This process will also verify the PV system production as modeled, and it will set a baseline for consideration of future O&M needs of the system.

We further believe that mitigation of revenue risk, aided by these suggested guidelines, will help the capital markets accept PV as an investment with lower risk and aid in moving PV to an acceptable asset class.

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