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Photovoltaics Technology in the Federal Marketplace: Understanding the Basics - Part II After the Installation

Aug 9, 2011

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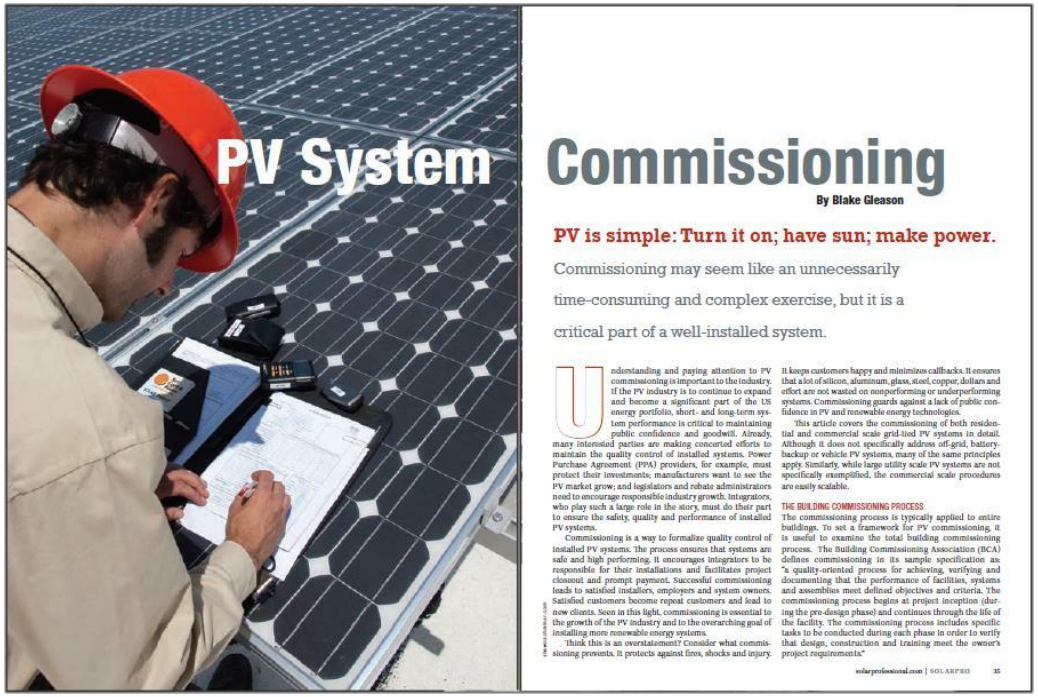
Outline of Presentation

- System Commissioning
- O & M
- System Monitoring
- Some Lessons Learned from the Field

PV System Commissioning

- The Building Commissioning Association (BCA) defines commissioning as: "a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems and assemblies meet defined objectives and criteria."



PV System

Commissioning

By Blake Gleason

PV is simple: Turn it on; have sun; make power.

Commissioning may seem like an unnecessarily time-consuming and complex exercise, but it is a critical part of a well-installed system.

Understanding and paying attention to PV commissioning is important to the industry. If the PV industry is to continue to expand and become a significant part of the US energy portfolio, short- and long-term system performance is critical to maintaining public confidence and goodwill. Already, many interested parties are making concerted efforts to maintain the quality control of installed systems. Power Purchase Agreement (PPA) providers, for example, must protect their investments; manufacturers want to see the PV market grow; and legislators and rebate administrators need to encourage responsible industry growth. Integrators, who play such a large role in the story, must do their part to ensure the safety, quality and performance of installed PV systems.

Commissioning is a way to formalize quality control of installed PV systems. The process ensures that systems are safe and high performing. It encourages integrators to be responsible for their installations and facilitates project closeout and prompt payment. Successful commissioning leads to satisfied installers, employees and system owners. Satisfied customers become repeat customers and lead to new clients. Seen in this light, commissioning is essential to the growth of the PV industry and to the overarching goal of installing more renewable energy systems.

Think this is an overstatement? Consider what commissioning prevents. It protects against fires, shocks and injury. It keeps customers happy and minimizes callbacks. It ensures that a lot of silicon, aluminum, glass, steel, copper, dollars and effort are not wasted on nonperforming or underperforming systems. Commissioning guards against a lack of public confidence in PV and renewable energy technologies.

This article covers the commissioning of both residential and commercial scale grid-tied PV systems in detail. Although it does not specifically address off-grid, battery-backup or vehicle PV systems, many of the same principles apply. Similarly, while large utility scale PV systems are not specifically exemplified, the commercial scale procedures are easily scalable.

THE BUILDING COMMISSIONING PROCESS

The commissioning process is typically applied to entire buildings. To set a framework for PV commissioning, it is useful to examine the total building commissioning process. The Building Commissioning Association (BCA) defines commissioning in its sample specification as: "a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems and assemblies meet defined objectives and criteria. The commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction and training meet the owner's project requirements."

solarprofessional.com | SOLARPRO 35

Reference:
SolarPro Magazine
October/November 2009

PV owners should contract with an outside commissioning ***specialist*** to oversee the commissioning process.

PV System Commissioning: Safety First

- All equipment inspections should be made with both utility and solar electrical sources switched off and locked out.
- *After* all inspections the equipment is ready to be energized at commissioning, often for the first time.

PV System Commissioning - Objectives

- Verify that all construction is complete and correct
  - All structural, mechanical, electrical components installed according to system plans
  - Verify Cable Insulation (Hipot)
  - Verify Concrete – to ASCE Standards
  - Verify Welds – to ASTM Standards
  - Verify Ground Continuity
  - Verify Roof integrity (no leaks)
  - Verify Torque on Mechanical and Electrical connections
  - Verify Breaker and Relay Settings

PV System Commissioning - Objectives

- Verify that the installation is safe
  - Verify that all working clearances meet code
  - Verify that all *NEC*-required labeling is present
  - Verify that good workmanship practices were followed throughout
- Verify that the installation is aesthetically acceptable
  - All elements are straight, parallel to roof features, plumb and level
- Verify that all components are robust and permanent
  - All equipment outdoor-rated
  - All wiring and raceways suitable for their location
  - All wiring connections and terminations are tight and corrosion-free
  - All wiring harnesses are neatly bundled and protected

PV System Commissioning - Objectives

- Document the final, as-built condition
  - Note in writing and photographs any discrepancies from existing plans
  - Document model number and quantity of modules, inverters, combiner boxes, disconnects, and monitoring equipment
- Verify sub-system *performance*
  - Megohm meter readings for all homerun wiring (to detect ground faults)
  - Measure Voc of each string (to verify strings have correct number of modules and correct polarity)
  - Follow inverter manufacturer's start up procedure, typically:
    - Verify correct ac voltage at ac disconnect
    - Verify correct dc voltage and polarity at dc disconnects
    - Install fuses, close disconnects, switch inverter "ON"

PV System Commissioning - Objectives

- Verify full system performance
  - With inverter operating:
    - Measure Imp for each string
    - Measure ac power output of inverter
  - Confirm system shuts down properly on loss of utility

- Record short and long-term system power/energy performance and compare to expected values

PV System Commissioning - Issues

- Many detailed contractual issues need to be addressed in acceptance or commissioning testing language
  - Adjustments for soiling (array cleaning schedule established?)
  - Cleaning of irradiance sensor
  - Time of year (need representative conditions)
  - Type of irradiance sensor - Pyranometer or reference cell
  - Thin film (aSi) seasonal variation
  - Light Induced Degradation (wait for completion?)
  - Measurement uncertainty (always important)

PV System Commissioning – The End

- As the final part of the commissioning process, the PV integrator or installer should train the owner on basic system operation
  - Training should include a physical walkthrough of the entire system, especially noting disconnect locations and procedures
  - Inverter operation should be reviewed, including any display screens and status lights.
  - Significant time should be dedicated to studying the monitoring system, if one is installed

PV System O&M *

Reference:
Nadav Enbar, EPRI
Presentation at DOE Workshop November 2010

* (Yes, PV systems require maintenance)

PV System O&M

- Variables that influence O&M requirements and cost
  - Site characteristics and environment
    - Systems size, type (e.g., roof mount, ground mount, tracker) and location
    - Number of distinct arrays, meters, inverters, and ease of access
    - Availability of water (for cleaning)
  - Scope of O&M services
  - Desired level of monitoring capability
  - Warranty terms
  - On-site vs. off-site management
    - Can affect labor cost 2-3x
- Over the life of typical Utility-scale systems, levelized cost of O&M will comprise 1-2% (typically) of the installation price

PV System O&M – Major Elements

- Preventive Maintenance
  - Array cleaning (1-2x per year, typically)
  - Vegetation managemen (1-3x per year, typical)
  - Retro-commissioning (1x per year)
  - Data acquisition and monitoring recalibration (variable)
  - Maintenance of power generation subsystems such as inverter servicing, BOS inspection, tracker maintenance (1-2x per year, typical)
- Corrective Maintenance
  - Critical repairs to address failures and production losses
  - Non-critical repairs to address production degradation
  - Warranty enforcement (as needed)

PV System O&M – In House vs. Outsourcing

- In-House Pros:
  - Better visibility on equipment issues; improved quality control
  - Ability to leverage existing assets and institutionalize O&M processes
- In-House Cons:
  - Requires upfront costs and workforce knowledge ramp up
  - Increased Risk
- Outsourcing Pros:
  - Lower up front costs and risk; less drain on personnel time
- Outsourcing Cons:
  - Less control/understanding of O&M processes
  - Dependence on outsourced contractors

PV System O&M – Warranties and O&M

- System warranties clearly outline responsibility for system repairs between plant owner, plant manager, and integrator, including:
  - Repair response requirements –“critical” vs. “non-critical”
  - System performance thresholds
- Three General Warranty scenarios
  - PPA: Warranty terms embedded in the PPA and are the integrator’s responsibility for the duration of plant lifetime
  - Ownership (outsource): owner contracts out to turnkey provider who handles warranty enforcement (pass through) for negotiated time period
  - Ownership (in-house): Owner responsible for all warranty enforcement

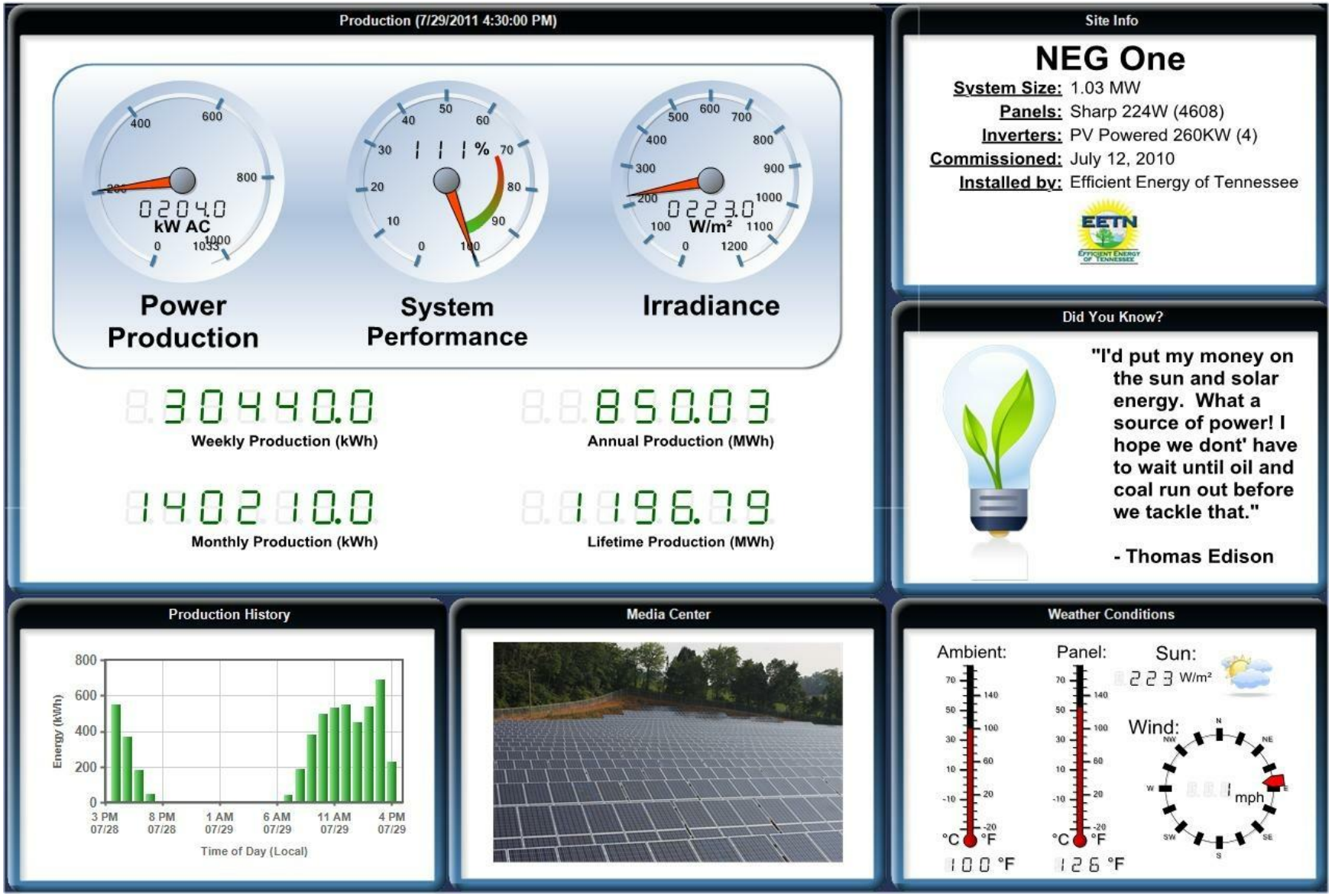
PV System Monitoring

- Why monitor?
  - Large systems are technically complex – monitoring allows a precise look at how the system is performing
  - Monitoring allows remote management and maintenance of the PV system, minimizing downtime
  - Monitoring can send automated alerts when system is underperforming or when failures occur
  - Monitoring logs system yield and enables “actual vs. expected” performance and trending analyses
  - Monitoring data can be collected locally or over the internet
  - Monitoring can be used for informational displays for employees or visitors

PV System Monitoring

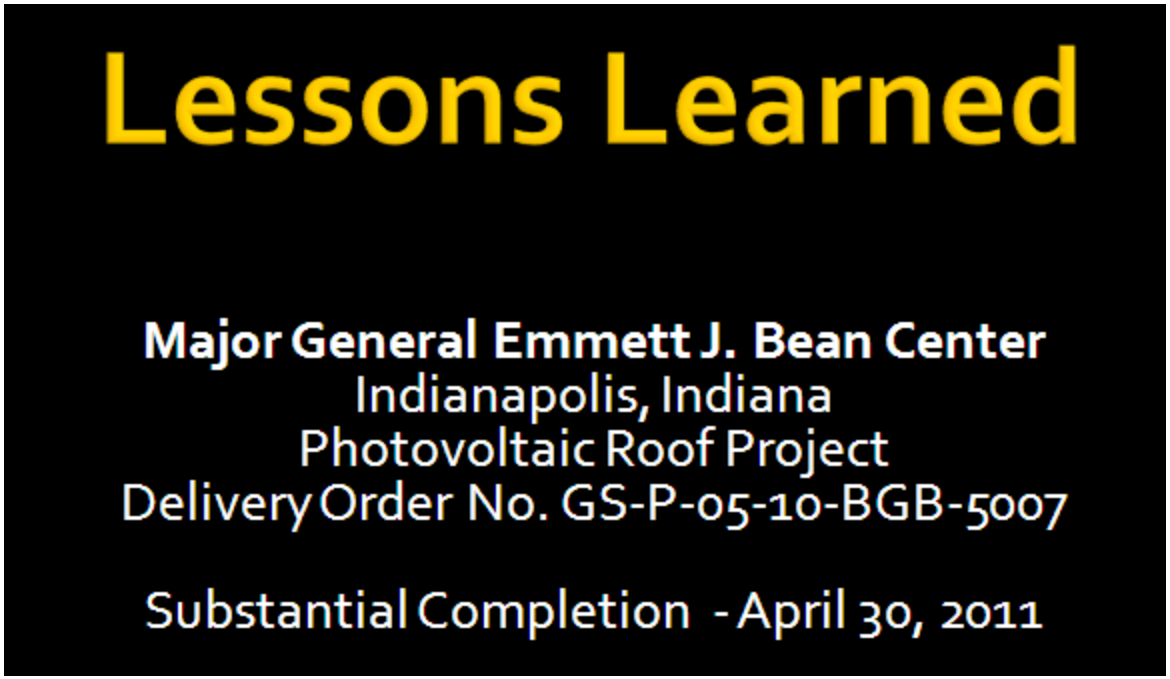
- Why is monitoring often overlooked?
  - Project focus is typically on installation of the PV system itself
  - Monitoring is always the last part of a project chronologically and more likely to be trimmed due to budgetary or time constraints
  - Monitoring extends past the installation completion date and can require a time commitment of several years that may not have been included in the budget
  - Monitoring of PV systems in-house requires training and expertise

PV System Monitoring – Sample Dashboard



PV Systems – Some Lessons Learned

- These notes come from a summary presentation given by the CMc (Contract Manager as constructor) for the recently completed 2MW PV system at the Major General Emmett Bean Federal Center (Indianapolis, IN)



PV Systems – Some Lessons Learned

- Mitigating Budget Risk
  - Ensure CMc has 100% final construction documents
  - Discuss in detail whether day or night shifts are best for the project
  - Discuss a proper budget for CMc to potentially provide badged personnel throughout entire project to escort subcontractor workforce
  - Define "minimal disruption" unambiguously with building's Property Management and with CMc and subs prior to bidding and GMP approval
  - Have the CMc and subcontractors submit work plans that focus on solutions when disruption does occur

PV Systems – Some Lessons Learned

- Scheduling: Best Practices
  - Before contracts are awarded, GSA, CMa and CMc should agree on scheduling software to be used (e.g. Suretrak, P3, P6, etc.)
  - Have the CMc submit work plans addressing how they will work through potential weather issues
  - Order additional panels at bid time to replace panels broken in shipment; replacement panels are not rushed through manufacturing and it may take months to get replacements
  - Involve the utility company during design to be sure correct equipment is included in the contract documents
  - Start negotiating the interconnection agreement between the Federal Agency and the utility company during design, i.e. it could take months

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PV Systems – Some Lessons Learned

- Communications and Relationships
  - Up front development of detailed work plans for the major phases of the work mitigates surprises during construction and fosters trust between customer, CMa, and CMc
  - Regarding Safety: CMc should educate the team on what to consider a "big" versus a "small" safety incident and the proper response
    - Recommendation: CMc provide weekly safety training classes on various topics to all the workers onsite and the team
    - Recommendation: CMc provide all required PPE to the team to ensure compliance (hard hats, glasses, vests, gloves, etc.)
  - CxA (commissioning agent) should be under contract at the same time as the A/E to help write and review specifications

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Thank You

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