Sandia National Laboratories
Photovoltaic and Grid Integration Dept.

Solar ABCs Stakeholder Meeting
October 23, 2014    Las Vegas, NV
Roger Hill, Sandia National Laboratories
# Sandia’s Work in O&M Related Standards

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>APPROACH</th>
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<tbody>
<tr>
<td>Improve O&amp;M Best Practices</td>
<td>1. Collect PV system event data</td>
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<td>Participate in and develop new O&amp;M standards</td>
<td>2. Determine gaps and what groups are addressing certain areas</td>
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<td>Mitigate PV system performance and financial risk by improving our knowledge of how reliability impacts O&amp;M activities</td>
<td>3. With working group, develop best practices that fill these gaps. Preventative maintenance, Availability-fault &amp; failure analysis-data collection-key performance indicators</td>
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<tr>
<td>§ Improve O&amp;M Best Practices § Participate in and develop new O&amp;M standards § Mitigate PV system performance and financial risk by improving our knowledge of how reliability impacts O&amp;M activities</td>
<td>4. Actively participate in ASTM ICOMP and IEC Maintenance standards development</td>
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<td>5. Submit Sandia working group efforts to Standards body (IEC) on Availability-fault and failure analysis-data collection-key performance indicators (KPIs)</td>
<td>6. Periodic Workshops and outreach</td>
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Precursor Report of Data Needs & Recommended Practices for PV Plant Availability, O&M Maintenance Reporting

Led by Roger Hill, in consultation with Sandia O&M Working Group

**Goal** - Provide descriptions of quantitative numerical metrics of PV plant performance, including clock time of failures, faults, restoration times, other outages and lost energy and related two way effects with the plant operational and maintenance (O&M) function

**Objectives** - ensure that a PV system will be ready as needed, will perform as intended and can be optimally maintained to be as close to fully-operational during its lifetime (embedded in reliability definition)

**Includes**: Data needed, KPIs, report format, NERC GADS, O&M, Availability

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**The good, the bad, and the ugly**

Good: O&M service providers engaged

Bad: Availability definitions are enigmatic, spastic, and problematic

Ugly: O&M Service providers charged with liquidated damages if the plant they didn’t specify, design or install underperforms
Data Users and Types
(stakeholder analysis illustration)

External data Users – Energy Production

- Insurer
- Retail Utilities
- Grid System Operator
- Power Market Organizations

Internal Data Users – Asset Management

- Project Developer, Designers, Specifiers
- Financiers, Legal, Policy Makers
- Maintenance Provider
- Plant Operator
- Owners

KPIs
- Energy
- Power
- Capacity Factor
- Other KPIs

Other
- Forecasting
- Scheduling O&M
- Parts/Components
- Labor
- Costs/Revenues

- Performance Modeling
- Lost Energy/Production Engineering
- Customer/Grid Requirements
- Availability

- Power
- Energy

- Internal Data Users
- External data Users

- Lost Energy/Production Engineering
- Performance Modeling
- Customer/Grid Requirements
- Availability
*A common basis for information exchange on performance indicators between owners, utilities, lenders, operators, manufacturers, consultants, regulatory bodies, certification bodies, insurance companies and other stakeholders in the wind power business. It is used to help define requirements to support clear understanding of contract terms.
<table>
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<tr>
<th>Condition State</th>
<th>Example</th>
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<tbody>
<tr>
<td>Full performance</td>
<td>Function with no limits or restrictions</td>
</tr>
<tr>
<td>Partial performance</td>
<td>Functioning with limitations and/or restrictions</td>
</tr>
<tr>
<td>Technical standby</td>
<td>Temporarily nonfunctioning due to controlled and/or predefined tasks required - e.g. self-testing, ramp-up</td>
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<tr>
<td>Out of environment spec</td>
<td>Operative but not functioning as the environment is out of design specs</td>
</tr>
<tr>
<td>Requested shutdown</td>
<td>Operative but stopped by an external request - i.e. curtailment</td>
</tr>
<tr>
<td>Out of electrical spec</td>
<td>Operative but not functioning as the electrical parameters are out of design specs - i.e. grid outage</td>
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<tr>
<td>Scheduled maintenance</td>
<td>Scheduled maintenance prevents system components from performing the intended functions</td>
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<tr>
<td>Planned corrective action</td>
<td>Actions required to retain, restore, or improve the intended functions that are not part of normal scheduled maintenance</td>
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<tr>
<td>Forced outage</td>
<td>Action taken as unforeseen damage, faults, failures or alarms are detected</td>
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<tr>
<td>Suspended</td>
<td>Activities in SCHEDULED MAINTENANCE, PLANNED CORRECTIVE ACTION and FORCED OUTAGE are interrupted or cannot be initiated due to personal safety or equipment integrity - e.g. extreme weather</td>
</tr>
<tr>
<td>Force Majeure</td>
<td>Extraordinary event or circumstance beyond the control of the parties, prevents the parties from fulfilling their obligations.</td>
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Some Insightful Definitions (among many)

**Predicted Energy**: The energy generation of a PV system that is calculated with a specific performance model, using *historical* weather data that is considered to be representative for the site. (IEC 61724)

**Expected Energy**: The energy generation of a PV system that is calculated with a specific performance model, using actual weather data collected at the site during operation of the system. (IEC 61724)

**Operational Availability**: Primarily an operator’s or user’s view of a system as a whole and measures how the asset was actually generating power and revenue (IEC 61400-26-1)

**Technical Availability**: Primarily a manufacturer’s view and measures how often the system/component operated as is was intended to operate (lost production due to maintenance as specified, environmental conditions outside of the specification, standby for internal checks, etc. are not considered as unavailable (IEC 61400-26-1)
PV O&M Working Group, continuing...

- Started in FY 13 to address reliability and O&M topics
  - We’ve met 13 times in FY 14, averaging 17 participants per meeting. Good representation of members from across industry
  - Providing invaluable insight with Gaps Analysis, Reliability | Availability | Data reporting | KPIs paper, and Availability flow charting

Availability is a large gap, in terms of how it’s defined in contracts, and impacts to performance
Summary:
• Faults in systems and failures of components affect availability
• Unavailability requires maintenance.
• Unavailability affects production negatively.
• Lost production affects revenues.
• Best practices and standards clarify requirement needs and expectations.

How? By providing a common basis for information exchange on performance indicators between and among stakeholders. They can be used to help define requirements to support clear understanding of contract terms.