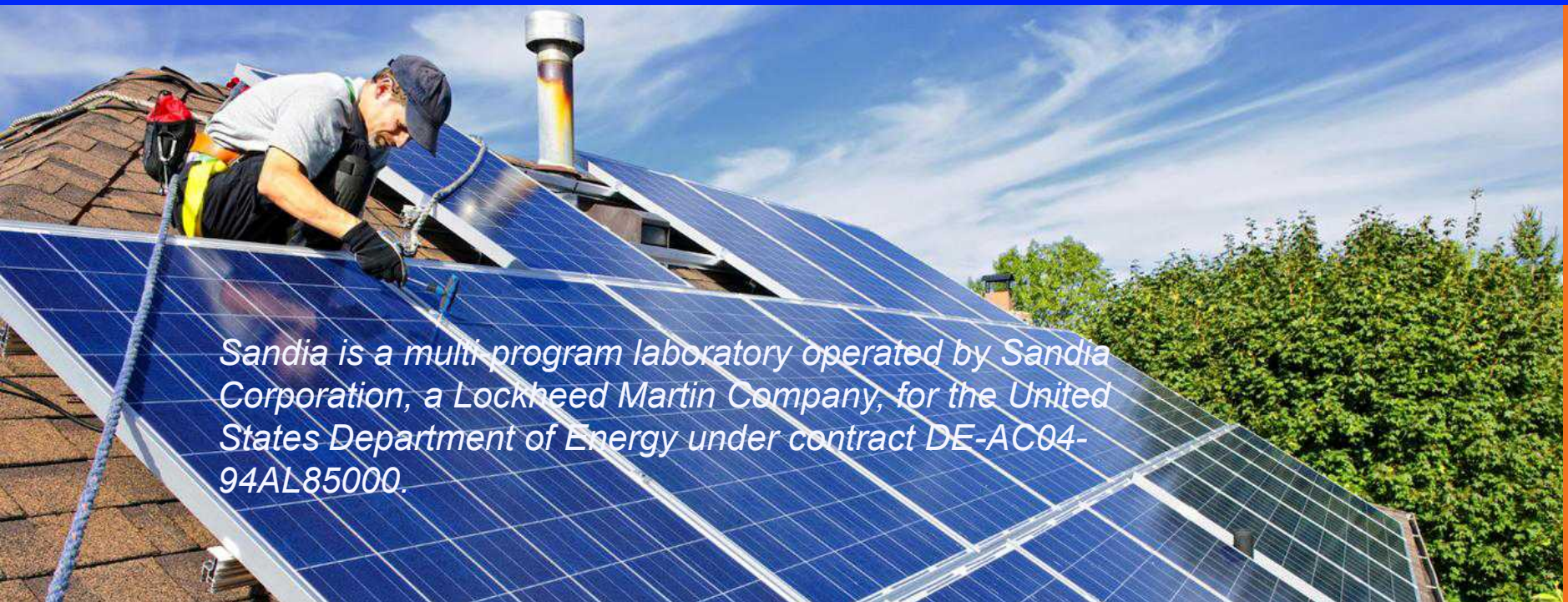


Mitigating O&M Risk Through Reliability Analysis

SAND2013-8246C

Utility-Scale PV Plant Optimization, San Jose, CA 9/26/13

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Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Mitigating Operations and Maintenance (O&M) Risk Through Reliability Analysis

- Understand how quality data can be used to improve PV system performance, quantify reliability, reduce O&M costs
- O&M drives long term costs and project performance. See how tools and techniques, combined with data analysis will lead to operational improvements.
- Hear how Sandia is working with O&M service providers to identify best O&M practices and create design and installation guidelines for O&M.

Technical Risks → Added Costs

Problem statement: Technical risks in PV plant operation lead to uncertainty in energy production – thereby, uncertainty in revenues. These “risks” include events, failures, repairs, replacements.

We are identifying, quantifying, and minimizing impacts of these risks in collaboration with the broad stakeholder community.

2-pronged approach:

- Partnering with the community to define and implement processes and metrics
- Analysis based on data from functioning systems

Impact: PV system cost reductions and greater investment

This project draws upon Sandia’s leadership with the wind industry

- Continuous Reliability Enhancements for Wind (CREW)
- IEC 61400-26 Availability Technical Specification for Wind Plants

Meteocontrol study of 30,000 PV systems in Europe found that 80% of these systems are underperforming expectations. <http://nyti.ms/16nXR7p>

“Lack of O&M standards and accurate cost information” O&M workshop <http://energy.sandia.gov/wp/wp-content/gallery/uploads/OM-Survey-Summary.pdf>

Technical Risks During Development

Risk	Considerations	Potential Damages or Losses
Resource Estimation	What level of confidence should be applied to historical solar data?	Resource-related production shortfalls Debt service delinquency or default
Component Specifications	What is the performance history or specification of the selected product?	Manufacturer insolvency Serial defects Infant mortality
System Design	How well is the system design integrated with the components? Does it ensure reliability, availability, and maintainability (RAM)?	Component failures Production shortfalls Forced downtime
Performance Estimates and Acceptance/Commissioning Testing	How well validated are the performance estimates? What tests are done to confirm baseline performance?	Production shortfalls relative to estimates—could stress debt service
Site Characterization	What is known and what might not be known about the site? What are the weather, water, geotechnical, and infrastructure conditions?	Environmental constraints/prohibitions Infrastructure constraints Transmission cost overruns
Transport/Installation Risks	Are components shipped and installed according to best practices?	Equipment damage delays

Technical Risks During Operation

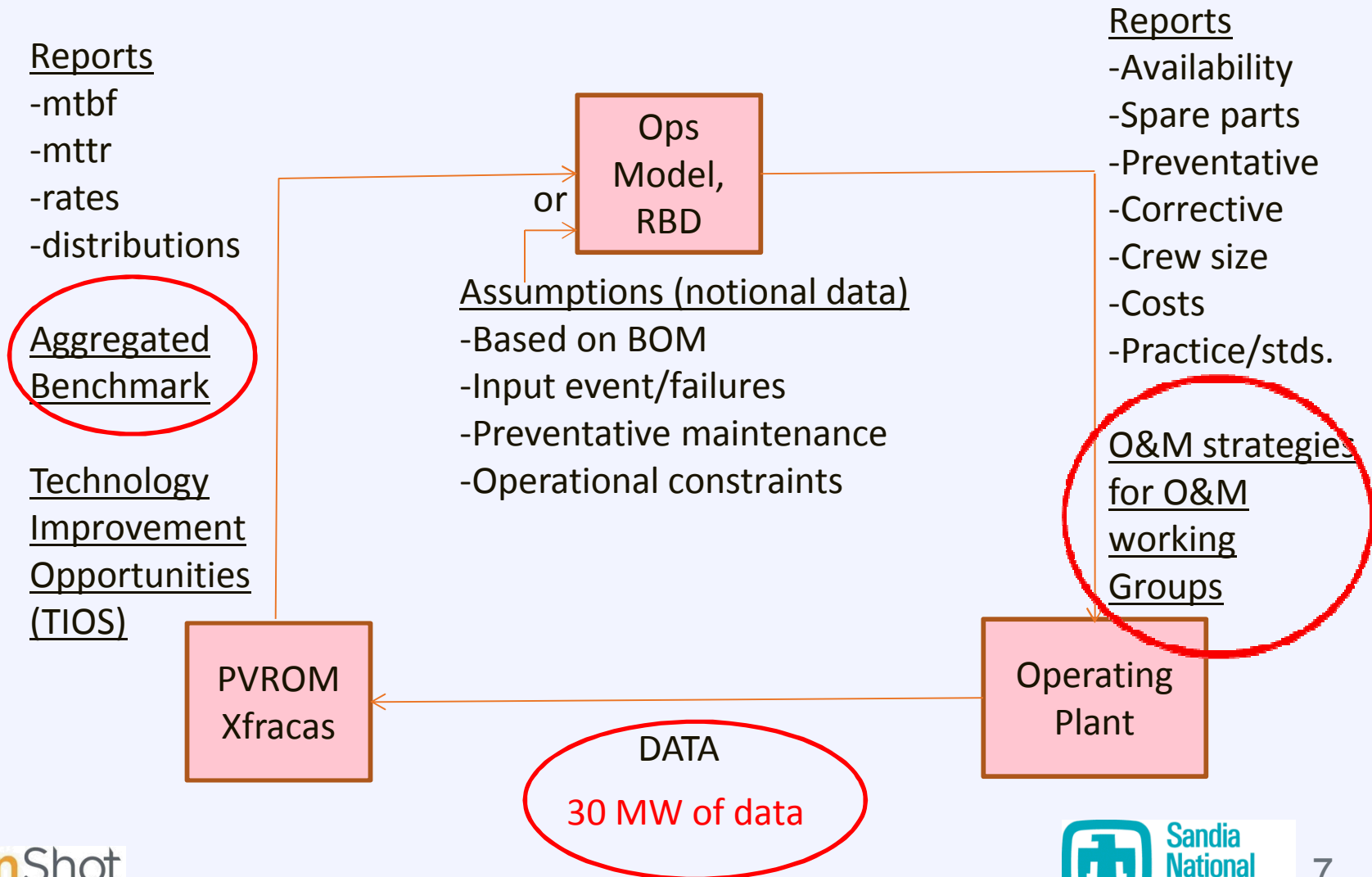


Risk	Considerations	Potential Damages or Losses
Operations and Maintenance (O&M) Risks	What are the component failure/reliability risks?	Serial failures
	Is there adequate availability of spare parts in inventory or rapidly available?	Latent defects
	What is the strength of the reliability assessment?	High rates of degradation
	What is the strength of the system design and production engineering?	Module delamination
	What is the production availability?	Forced outages
	Are there equipment warranties? Are the manufacturers still able to service them?	Planned and unplanned maintenance downtime and costs
	How strong is the O&M provider?	Manufacturer insolvency
	Off-Taker Infrastructure Risks	Is the power purchaser adequately equipped to integrate solar power resources?
Curtailment Inability of grid operator to handle variability		

Goals, Objectives, and Tasks

Goals & Objectives	Tasks (3 years)
Compile real field data to accurately characterize O&M technical risks	1. Develop a growing partner base with solar industry stakeholders
Gain knowledge and insight to minimize risk through better understanding of events and failures	2. Facilitate increased, accelerated, and broadened data flow; develop analytical tools
Broad adoption of standard definitions and approaches to identify and mitigate O&M-related risks	3. Engage with the community to assure input, relevance, and adoption of standardized results. (Integrate Reliability)

Through Partnerships/Data, a Continual Process of Feedback and Improvement



Data Collection Tool

SNL's PV Reliability O&M (PVRM) Database

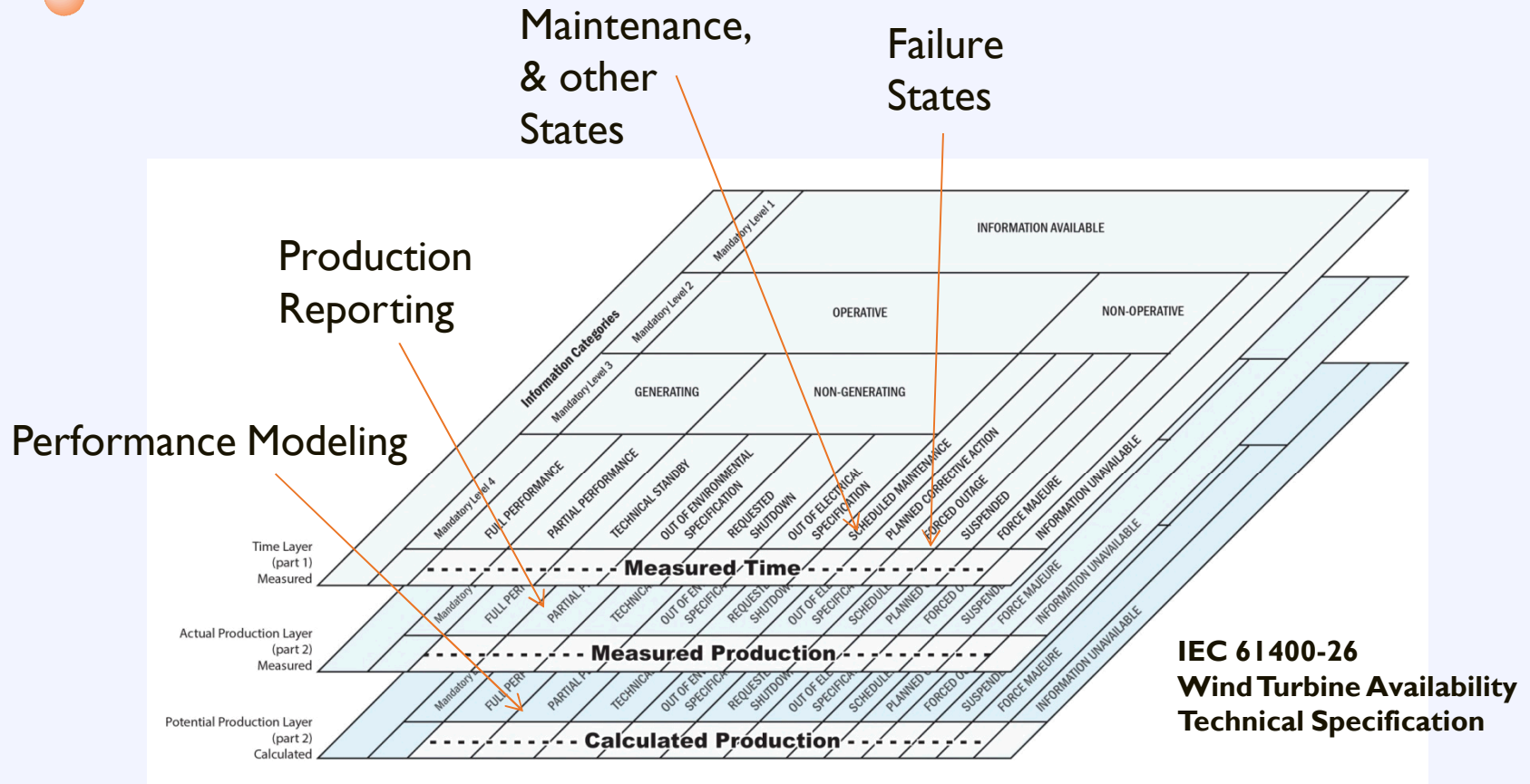
- Web-based incident (failure) reporting, analysis, and corrective action system software package (ReliaSoft's XFRACAS™)
 - FRACAS (Failure Reporting, Analysis and Corrective Action System) is a process for reporting, classifying, analyzing failures, and planning corrective actions in response to those failures
- Supports acquisition, management and analysis of system quality and reliability data from multiple sources
- Database resides on Sandia Restricted Network (SRN) server
- Access to database is through Sandia Open Network (SON) protocols
 - Access restrictions (login ID and password) ensure only source users (partners) can access database
 - SNL issues SON login ID and passwords
 - Only system owner and EPRI/Sandia will have access to O&M data
- XFRACAS™ source permissions ensure source users can access only their own data

Data Collection Tool (cont.)

SNL's PV Reliability O&M Database (cont.)

- XFRACAS™ platform supports both real-time and legacy failure/suspension (or non-failure event) data acquisition
 - Real-time incident records created via Incident Wizard and Incident Tracking Utility
 - Legacy data imported into database via Excel template
- Supports incident record searches and report generation
- Supports export of data to ReliaSoft reliability life data analysis and reliability growth analysis software products, which allow SNL to perform predictive analyses, sensitivity studies, and optimize operations and maintenance strategies
- Program partners may use other XFRACAS™ capabilities as well (e.g., failure analysis, corrective action tracking, etc.)
- The XFRACAS™ feature enables a suite of additional capabilities

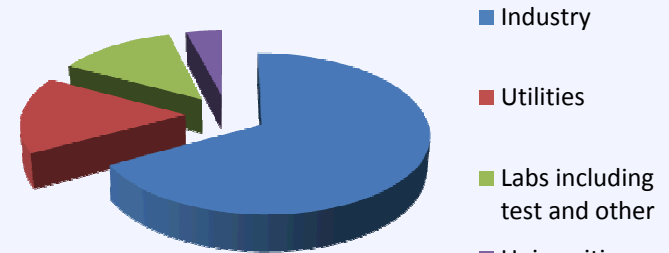
Working Group Example: Data Reporting for Utility-Scale Plants*



*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.

Working Toward Community Adoption

- Conducted O&M workshop
 - 84 registrants, predominantly industry
 - Issues defined and documented
 - 40 volunteers to join working groups
- Formation of O&M Working Groups
 - 1. Definitions Cary Fukada, PV O&M Manager, Chevron Energy Solutions; Colin Hamman, Sandia (co-facilitators)
 - 2. Best Practices Carter Wall, Director, Performance Solar Division, Broadway Renewable Strategies; Roger Hill, Sandia (co-facilitators)
 - 3. Design and Installation Rue Phillips, CEO, True South Renewables; Roger Hill, Sandia (co-facilitators)
 - Mission statement created, Charters under development
- Engagement with financial stakeholders
 - Mosaic/truSolar – SNL provided O&M criteria to support financial scoring protocols
 - TruSolar Members: ABB, ABM, Assurant, Booz Allen Hamilton, Distributed Sun, DuPont, Mosaic, PanelClaw, PWC, Rocky Mountain Institute, SMA America, Standard & Poor's, and Underwriter's Laboratories.
 - Working toward Credit Screening Criteria and Methodology (CSCM)

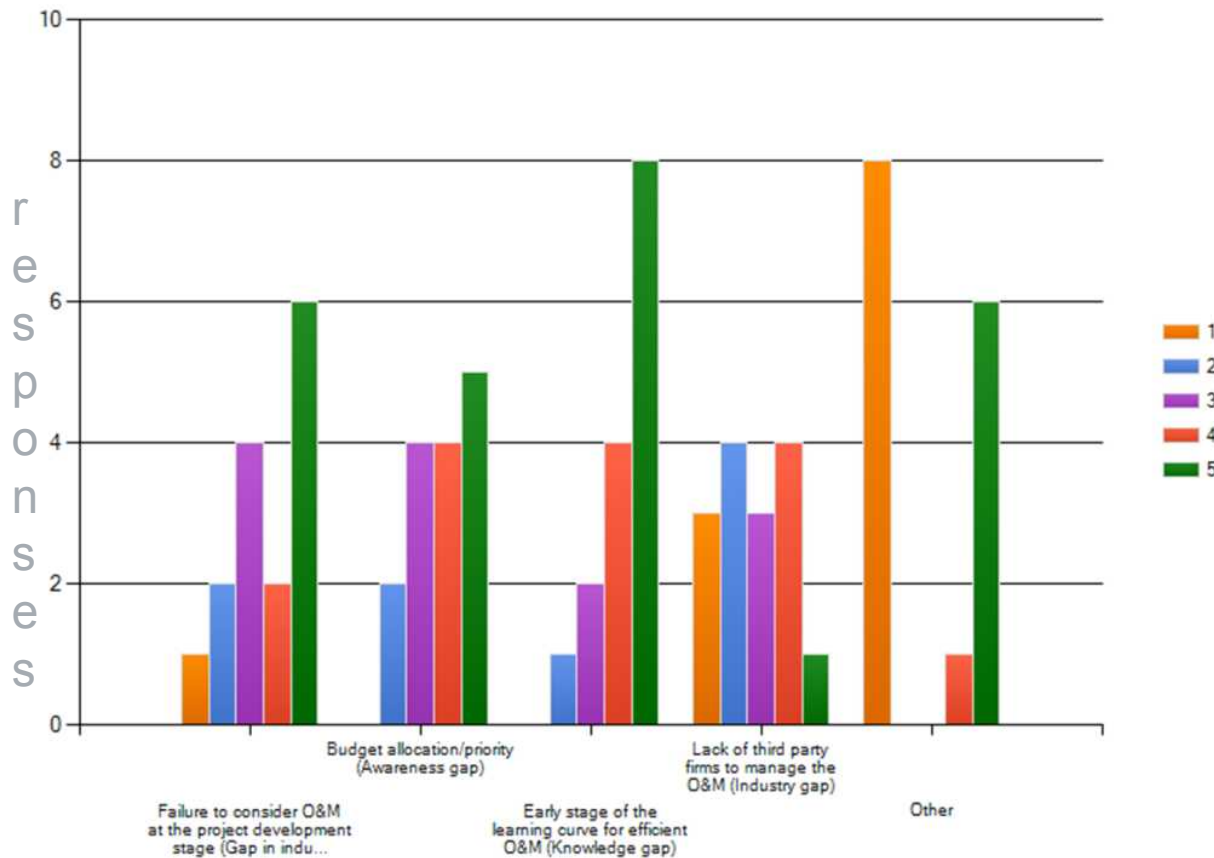


Sandia/EPRI PV O&M Workshop

- **Operations and Maintenance (O&M) for PV plants**
Basic business propositions like the need for maintenance at all, budgets set appropriately, need for O&M to be considered early, and appropriate scope for O&M, learning curves, asset management, “guessed practices” by banks, standard terms,
- **Data**
O&M planning is tenuous without data, aggregation valuable, trending, needed for financials, needed to model O&M, preventative maintenance advantages, cultural shift from competition to collaboration, data in language of financials, sensitive information, “Warts”
- **Warranties**
O&M dictated by keeping warranties honored, who pays and who shares risk, replacements strategies and logistics, enforceability, lawyers, insurance, many hoops,
- **Standardization/Best Practices**
Best practices, Safety #1, don’t see standards for O&M, O&M requirements, performance reporting, what can we use from other industries, definitions, terms, best practices, quality, training/continuing education
- **Working groups formed**

Background: Lessons learned from Workshop

Rank the most pressing PV reliability and O&M challenges (1: low, 5 high)

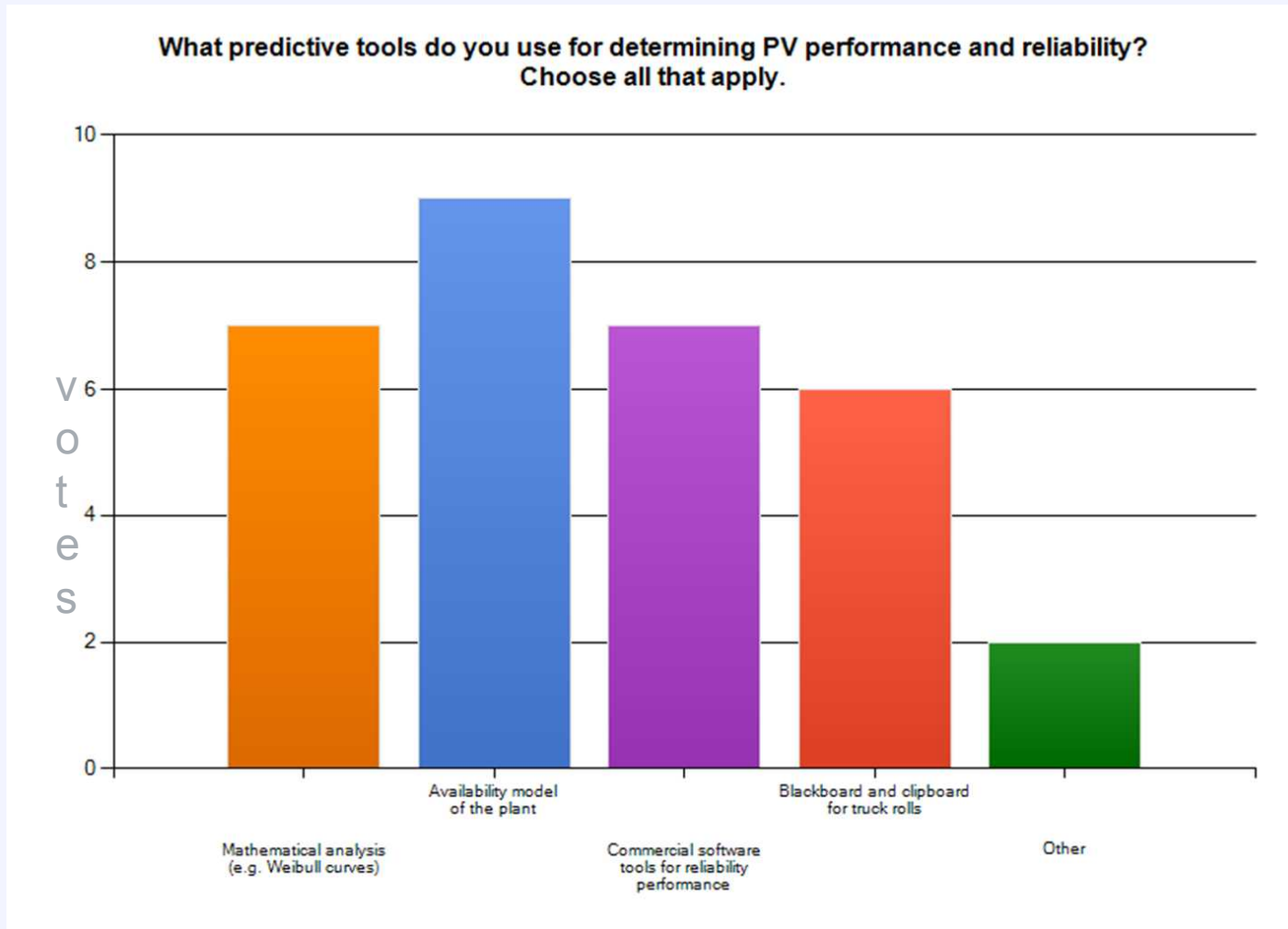


Other:

- SCADA/DAS optimized as O&M tool
- A lack of O&M standards and accurate cost information.
- Let's build... Who care about 20 years?
- More standardized data
- Premature inverter failures, unplanned extended outages early in project

Survey: <http://energy.sandia.gov/wp/wp-content/gallery/uploads/OM-Survey-Summary.pdf>

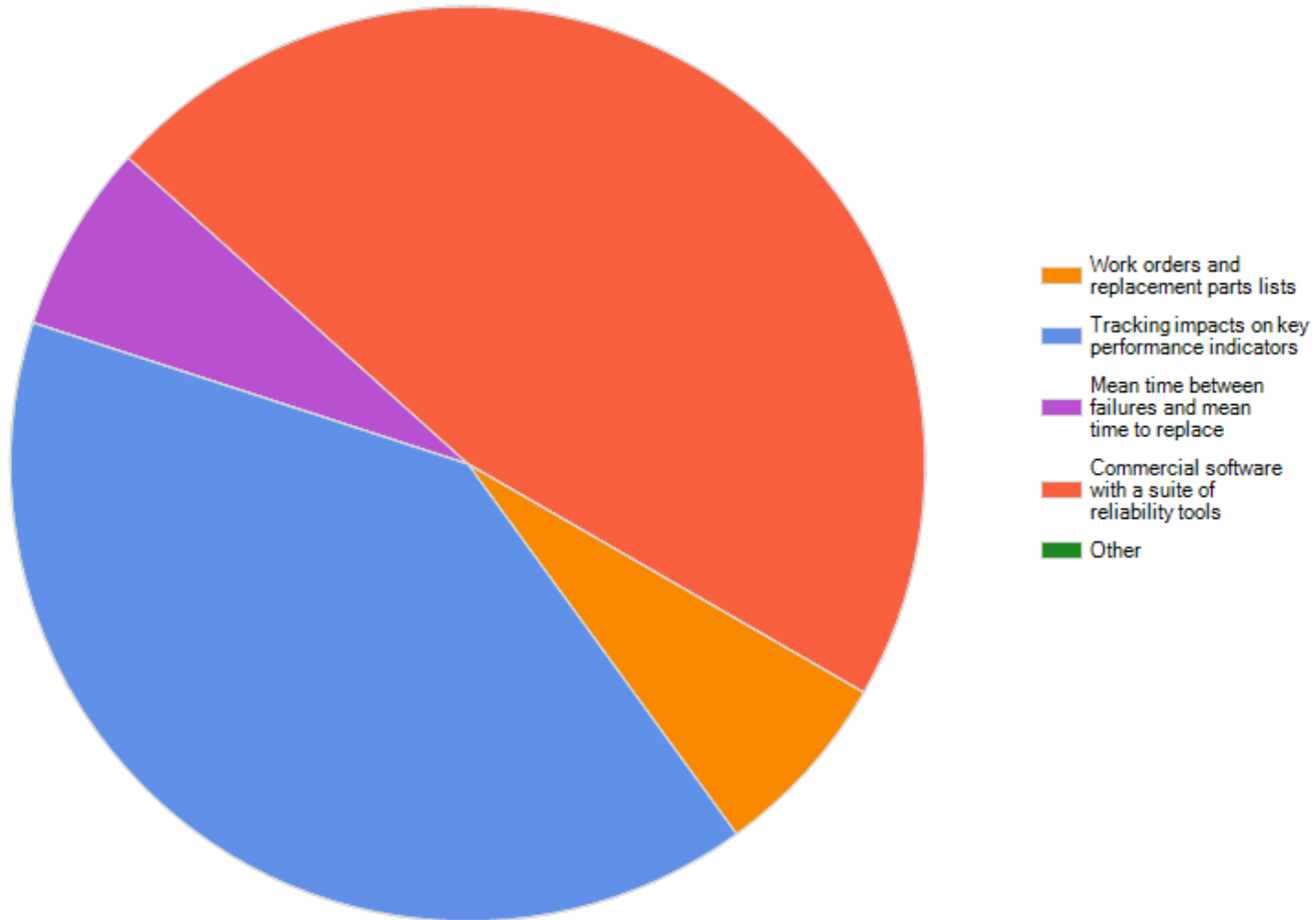
What is the current practice?



Survey: <http://energy.sandia.gov/wp/wp-content/gallery/uploads/OM-Survey-Summary.pdf>

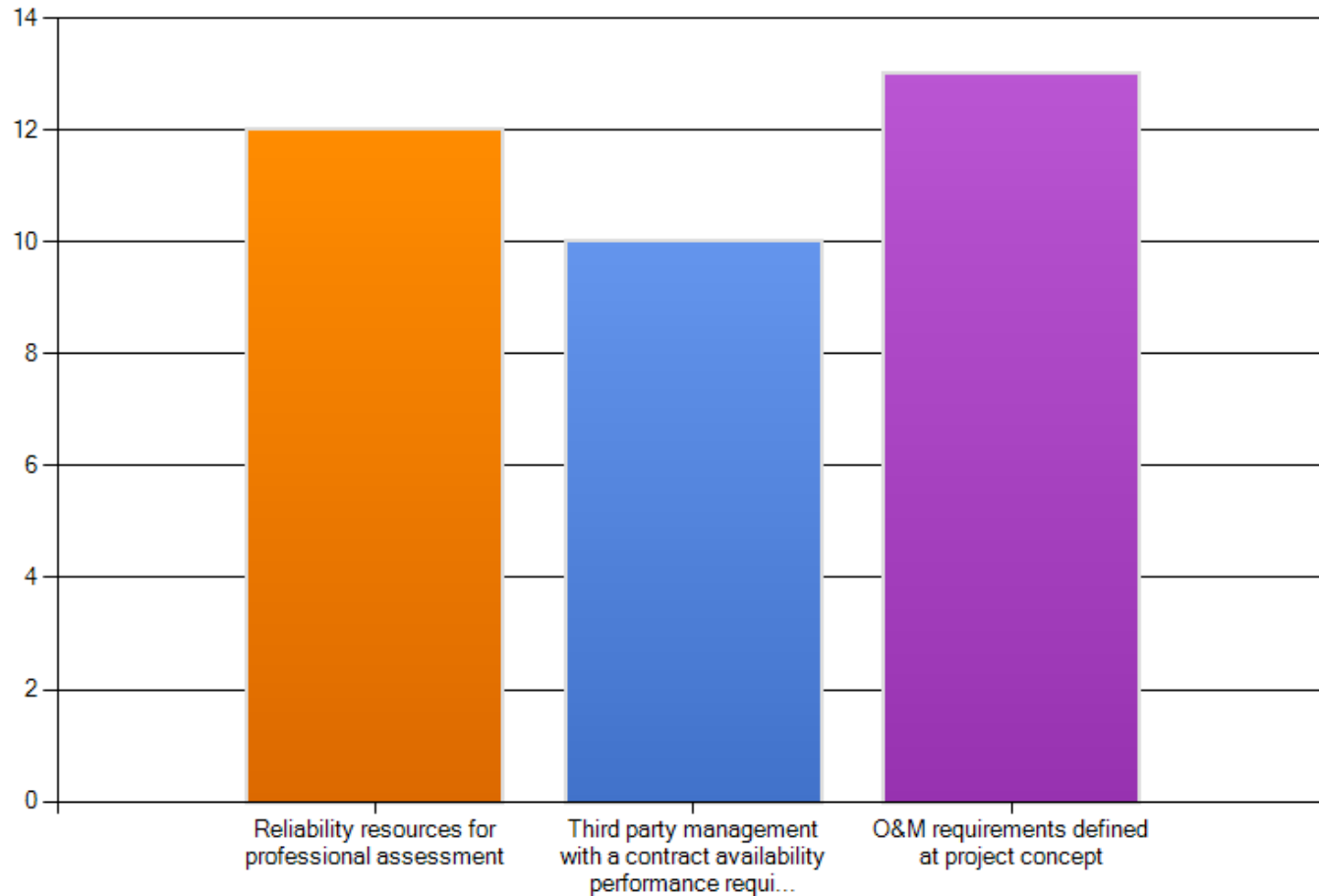
Level of Detail?

What is the right level of detail for tracking repairs and replacements?



What can be done?

What is and can be done to realize plant performance and cost improvements? Choose all that apply.



O&M Working Groups

Mission Statement: To facilitate PV industry maturity by creating standard definitions, more effective best practices, guidelines and standards, through systematic phases of design, installation, operations and maintenance. This will result in systems, which are lower risk, more cost effective, robust, reliable, more predictable and productive in performance, yield, lower O&M costs and longer functional life.

O&M Working Groups Definitions

Definitions

Reliability	Operative
Availability	Generation
Maintainability	Key performance indicators
Design specification	Full performance
Repair	Partial performance
Retrofit	Not generating
Up time	Technical standby
Down time	External conditions
Total time	Out of electrical specification
Event	Out of environmental specification
Failure	Forced outage
Preventative maintenance	Degradation (of plant)
Corrective maintenance	Degradation of modules
Predictive maintenance	Derated
	Data available or unavailable

O&M Working Groups

Best Practices

- Safety #1
- Training
- Failure analysis and reporting
- Interconnection
- Preventive maintenance practices/list
- Cleaning/soiling best practices

Design and Installation

- Safety #1
- O&M budget
- Vegetation Control
- Standard signage
- Commissioning
- O&M checklist

Definition of a Standard

"A prescribed set of rules, conditions, or requirements concerning definitions of terms; classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices."

National Standards Policy Advisory Committee



Why a standard?

To achieve a level of safety, quality and consistency in the products and processes.

Standards are vital tools of industry and commerce. They provide the basis for buyer-seller transactions.

Questions and Discussion





SunShot

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