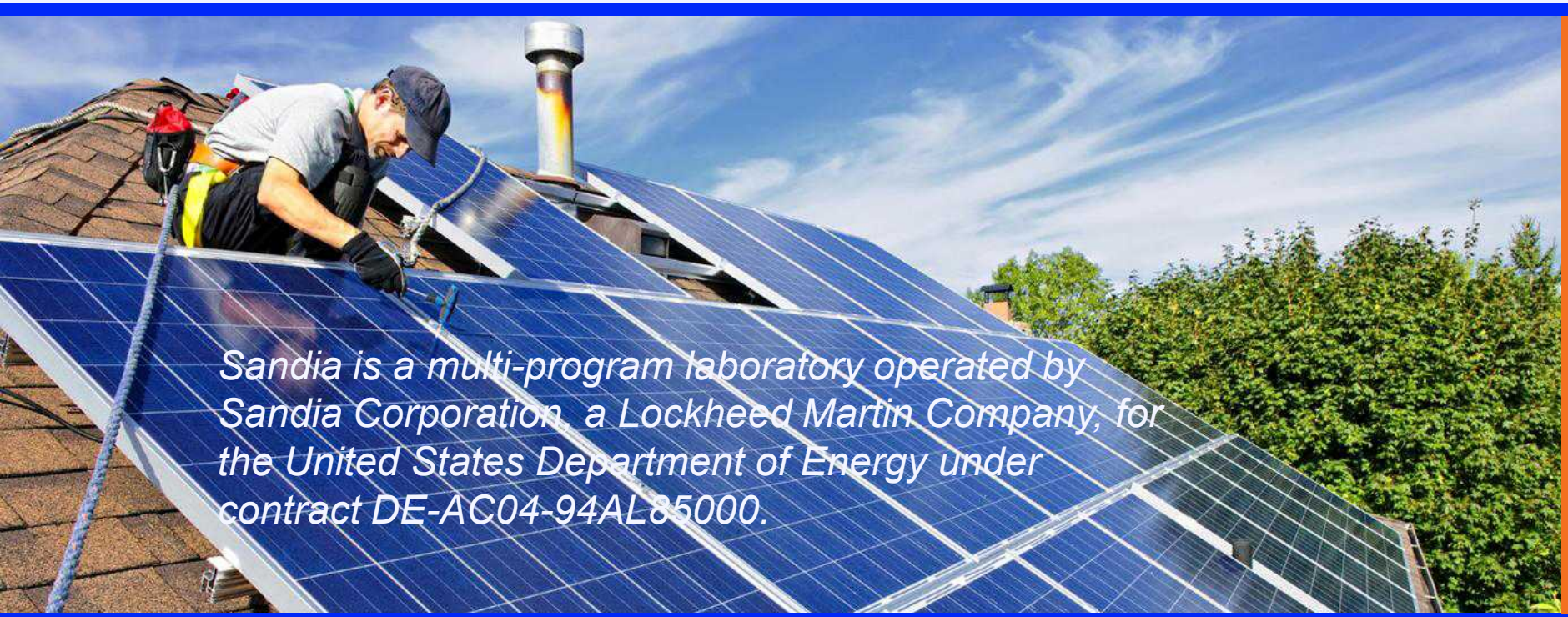
Chairman's Remarks
Mitigating O&M Risk

SAND2014-0918C

Solar Power Generation USA Congress 2014
Optimizing Solar Power Generation

Roger Hill: Sandia National Laboratories - Principal Investigator



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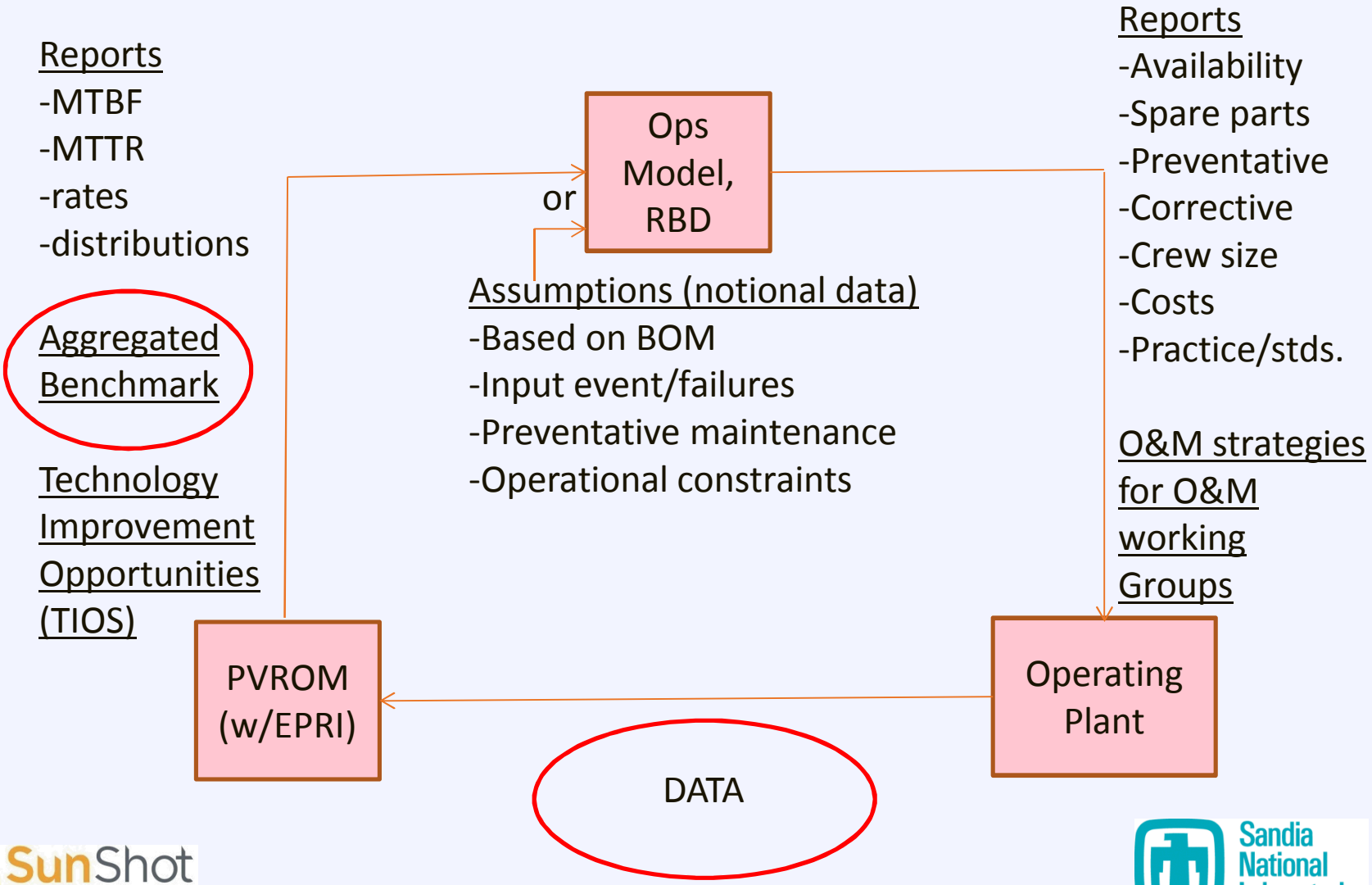
Mitigating Operations and Maintenance (O&M) Risk Through Reliability Analysis

- Understand how quality data can be used to improve PV system performance, quantify reliability, and 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 improved O&M

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



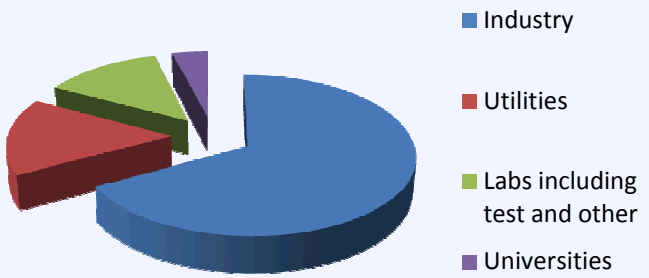
Data Collection Tool

SNL/EPRI PV Reliability O&M (PVROM) Process

- 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
- Includes Bill of Material (BOM), sometimes know as the taxonomy
- Events and failures are the inputs
- Reliability, availability, and maintainability (RAM) metrics are the results
- Database resides on Sandia Open Network (SON) server w/security protocols

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)
- Engagement with financial stakeholders

Sandia/EPRI PV O&M Workshop

- Workshop materials are at http://energy.sandia.gov/?page_id=2727
- **Operations and Maintenance (O&M) for PV plants**

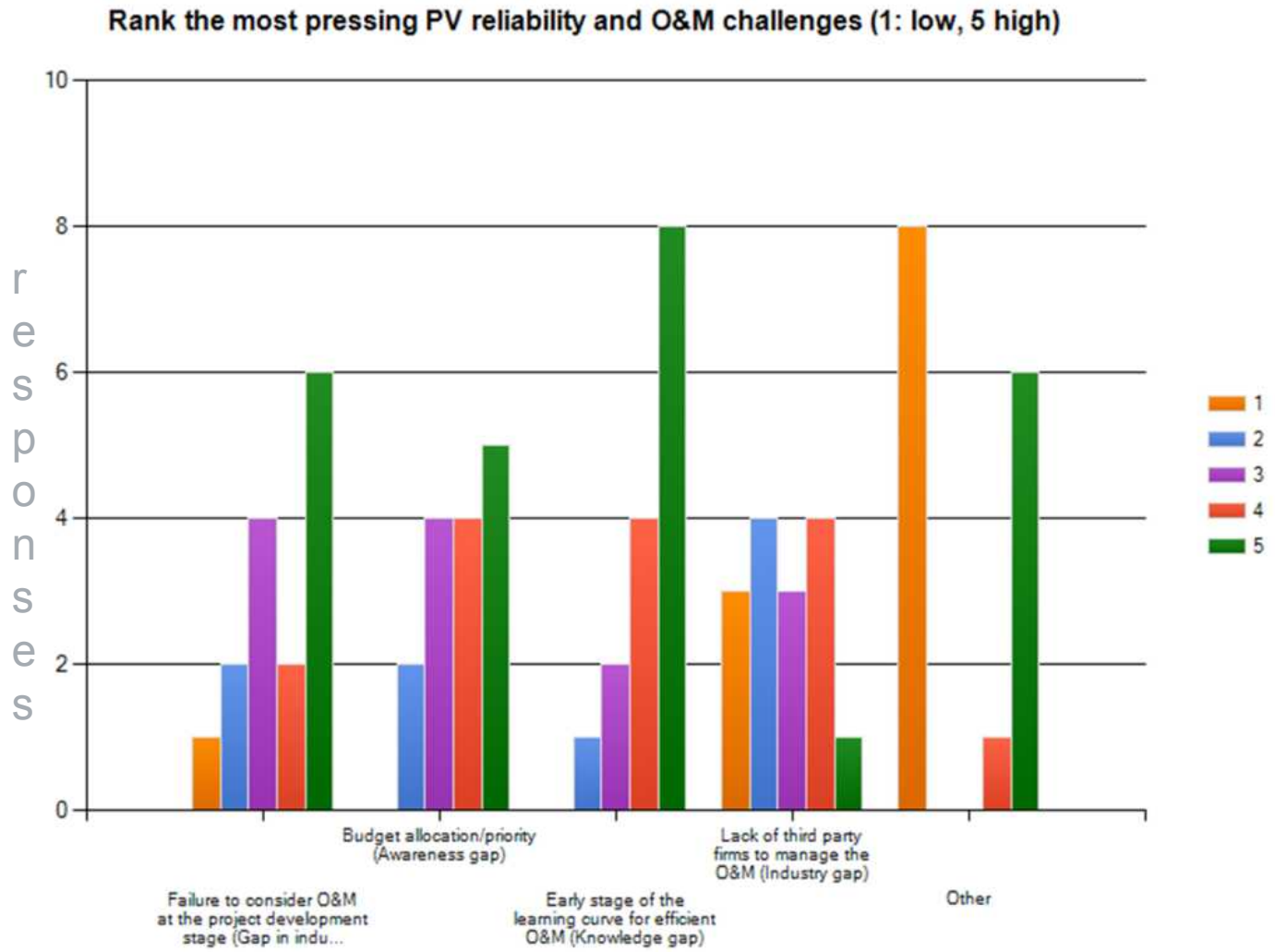
  Basic business propositions like the need for maintenance at all, budgets set appropriately, need for O&M to be considered early, and appropriate scope for O&M, learning curves, asset management, “guessed practices” by banks, standard terms
- **Data**

  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

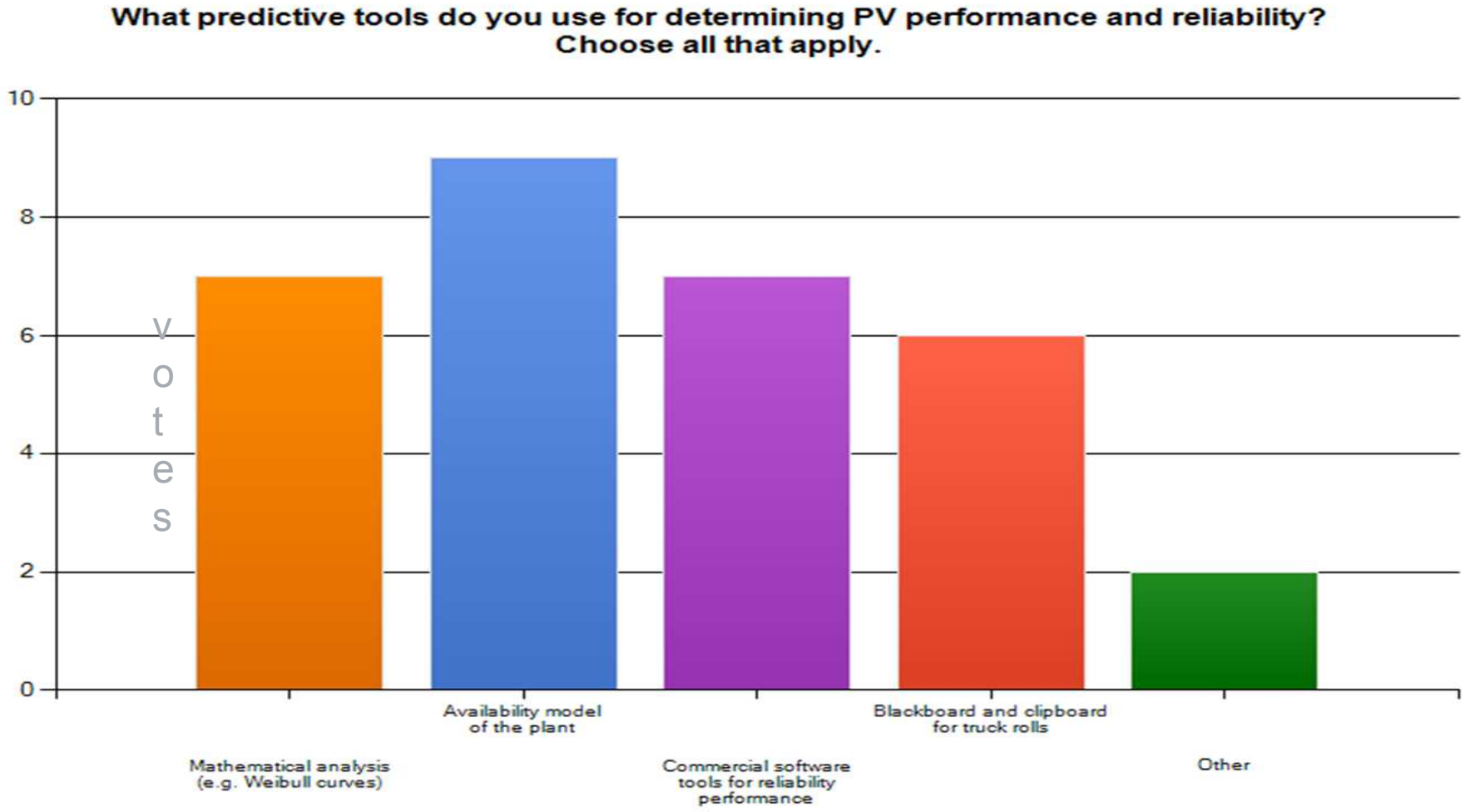


Other:

- 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

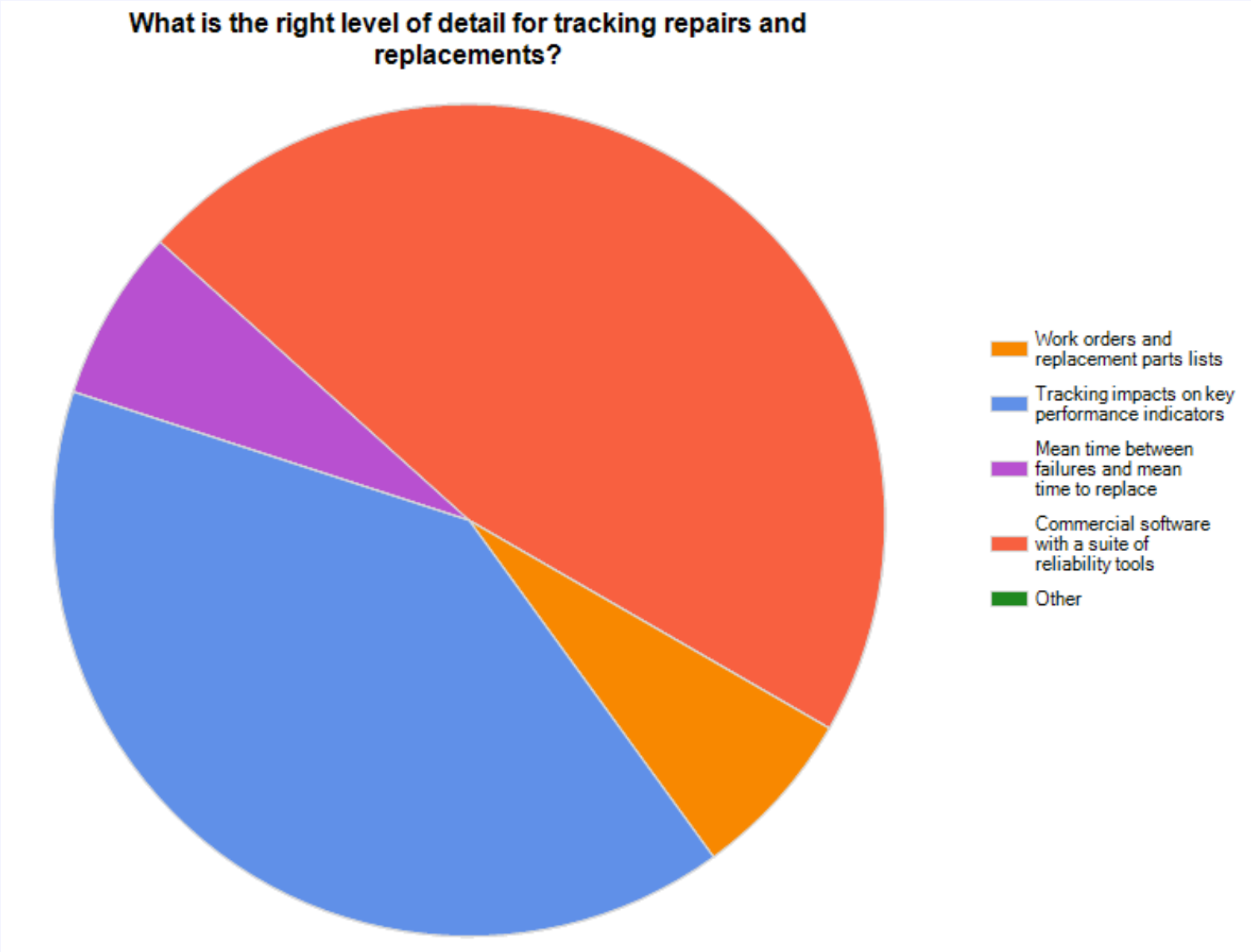
http://energy.sandia.gov/wp/wp-content/gallery/uploads/OM-Survey-Summary.pdf

What is the current practice?

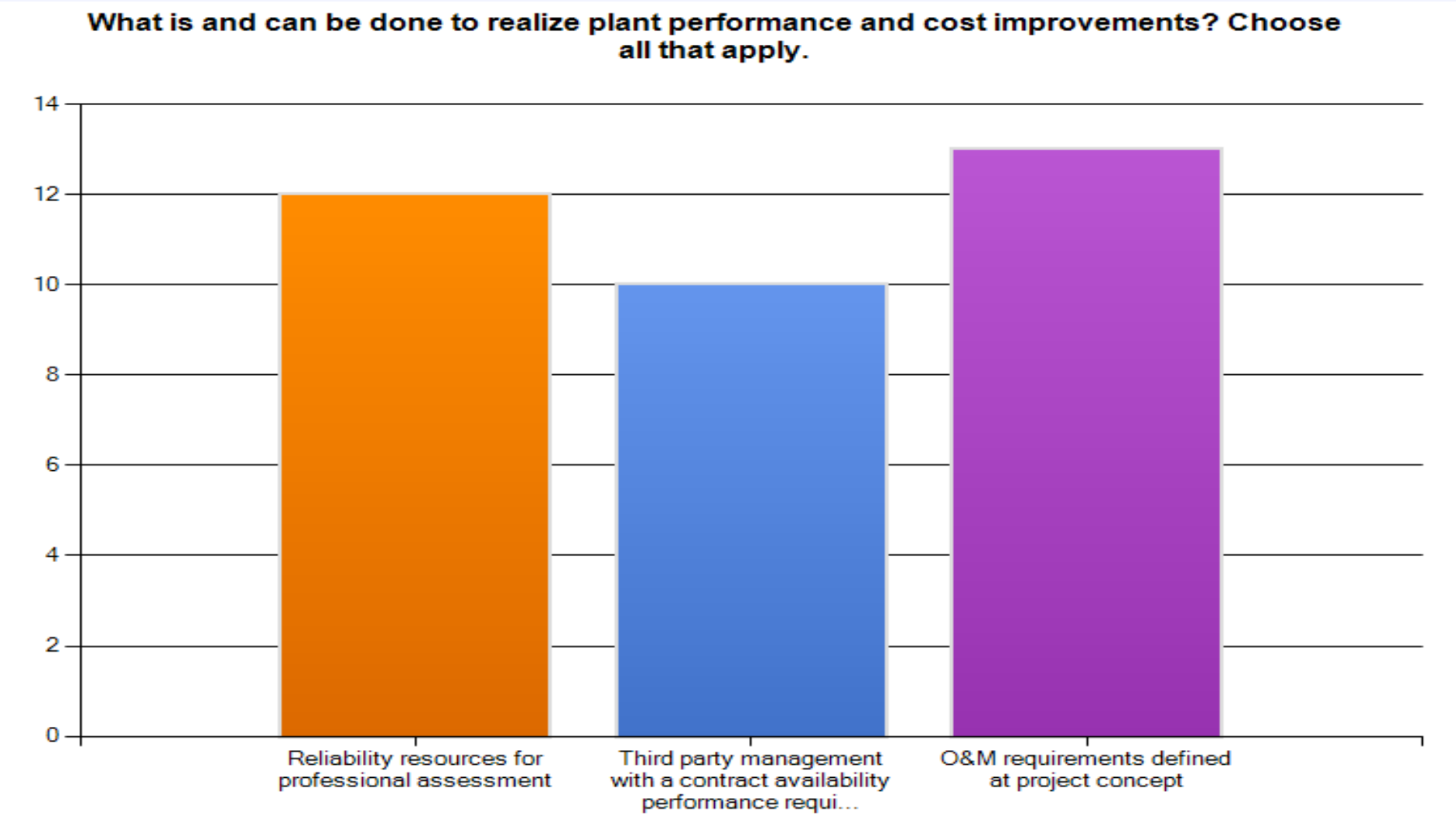


http://energy.sandia.gov/wp/wp-content/gallery/uploads/OM-Survey-Summary.pdf

Level of Detail?



What can be done?



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.

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

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Addition Information

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**

Source: Continuing Developments in PV Risk Management: Strategies, Solutions, and Implications: NREL/TP-6A20-57143 February 2013

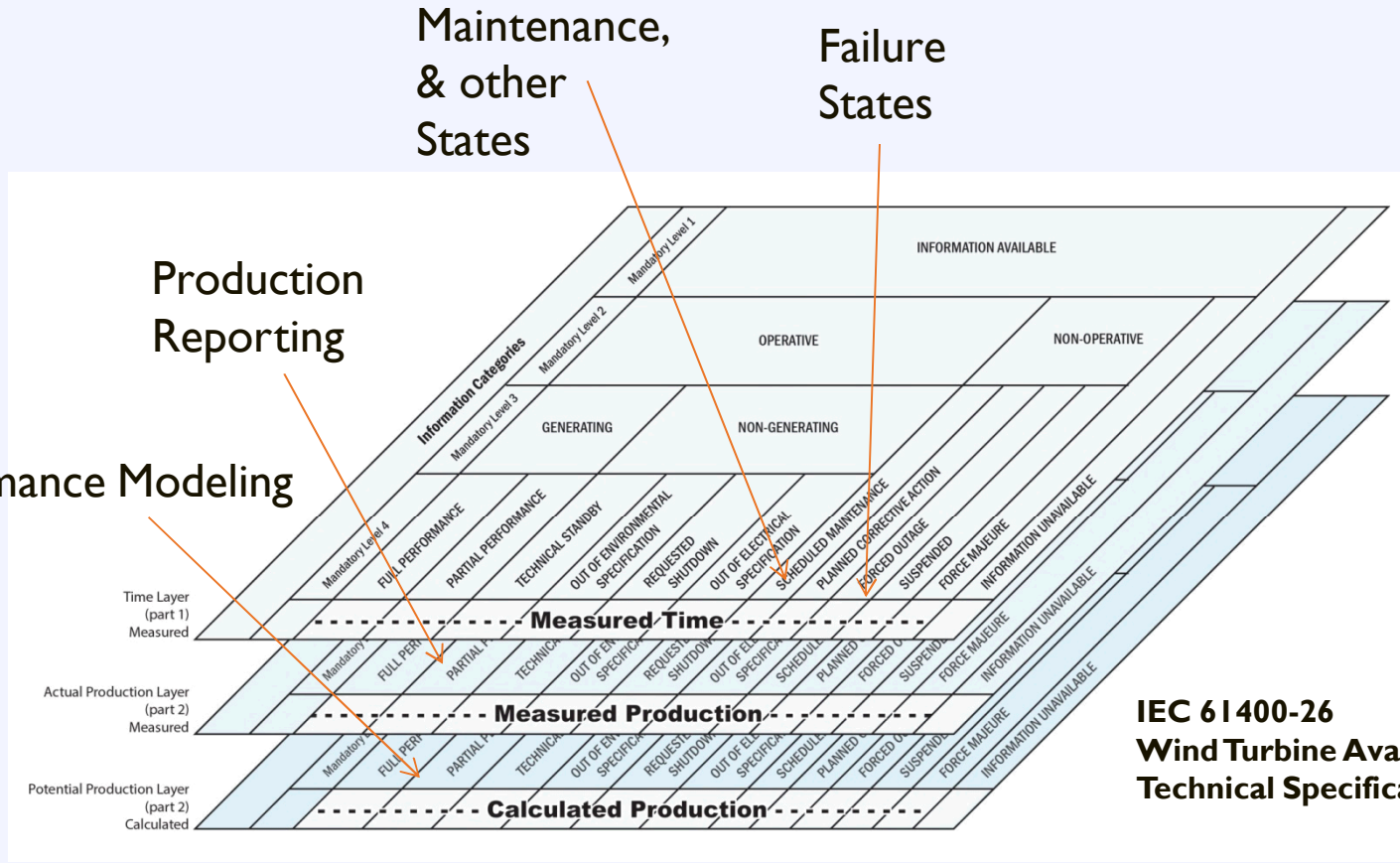
Technical Risks During Operation

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

Summary: Goals and Objectives

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)

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



IEC 61400-26
Wind Turbine Availability
Technical Specification

*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.