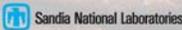# PV System Energy Performance Evaluation: Update from Sandia

October 7, 2010
Joshua Stein, Ph.D.
Sandia National Laboratories

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Applications of PV Models

- **Models estimate energy produced from PV systems**
  - **Compare different climates, technologies, and system design options**
  - **Evaluate shading, soiling, and other derate impacts**
  - **Calculate financial implications of design decisions**
- **Models used to monitor system performance**
  - **Model results provide a baseline that can be compared to monitored performance. Deviations are used to identify problems (degradation or component failure)**

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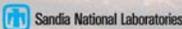
Current Status of PV Performance Modeling

- **Models Do Not Agree**
  - **Even the same model, applied by different users may produce different answers**

- **Model accuracy and uncertainty, in general, have not been independently verified**
  - **Uncertainty (x ± y) generally not stated**
  - **No accepted validation process**

- **Potential impacts include**
  - **Choosing a technology because the model associated with an incentive treats it favorably**
  - **Choosing a technology based on performance that is not a better value when uncertainty is considered.**
  - **High market hurdles for new technologies lacking extensive field performance data to justify tweaking models**
  - **A decrease in investor confidence, leading to higher financing costs**
- **Sandia organized a workshop to begin to address these issues**

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PV Performance Modeling Workshop
September 23-24, 2010, Albuquerque, NM

- **Attended by 50 including Modelers, Manufacturers, Integrators, Independent Engineers, Analysts, Universities, and National Labs**
- **Organized to assess the state of the art of modeling and to identify opportunities for improvement.**
- **Preliminary Summary of Outcomes**
  - Model developers are improving their models to boost accuracy for all technologies
  - All models, even the simplest, require user estimates for some inputs, e.g. derate factors in PVWatts
    - Modelers in same company using same model may get significantly different results
    - Experienced project developers have tuned models to match output of fielded systems and/or have developed internal models
    - Model tuning and validation requires data on fielded system performance with accompanying weather data
      - Public data is not available
  - Modelers who lack system data for model tuning and/or who are modeling new technologies will likely produce varying estimates of annual output, as illustrated by analysis of the workshop pre-work.
  - Needs
    - Validated data for model inputs, e.g. from 3rd parties
    - Standard sets of data from public installations of a variety of systems types and locations for use in model validation and improvement
    - Characterization of model uncertainty, including which inputs have greatest effect.

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Manufacturers
Abound Solar
BP Solar
First Solar
Miasole
SoloPower
SunPower
Uni-Solar
Yingli

Integrators
American Capital
Energy
Borrego Solar
Sun Edison

Independent Engineers
BEW Engineering
Black and Veatch
Luminate

Consultants/Analysts/Others
Steve Ransome
Navigant
SolarTech

Modelers
CEC-UW
Clean Power
King Solar Works
PVDesign Pro - Hoes Engineering
PV*Sol
PVSyst

Universities
U of Arizona
U of Colorado
U of New Mexico
U of Wisconsin

Labs/Government
National Institute of
Standards and Technology

National Renewable Energy
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Objectives for the Meeting

- **Assess the state of performance modeling**
- **Educate each other about needs, concerns, and possible paths forward**
- **Prioritize work to best meet the needs of the PV community**
  - **What must be done to improve module performance modeling?**
  - **How to ensuring quality in model inputs?**
  - **Should uncertainty be included in model outputs?**
  - **Validating models and inputs - are new standards needed?**
  - **Prioritization of future efforts, roles, and responsibilities**

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