



Summary of First PV Performance Modeling Workshop

Christopher Cameron
Consultant

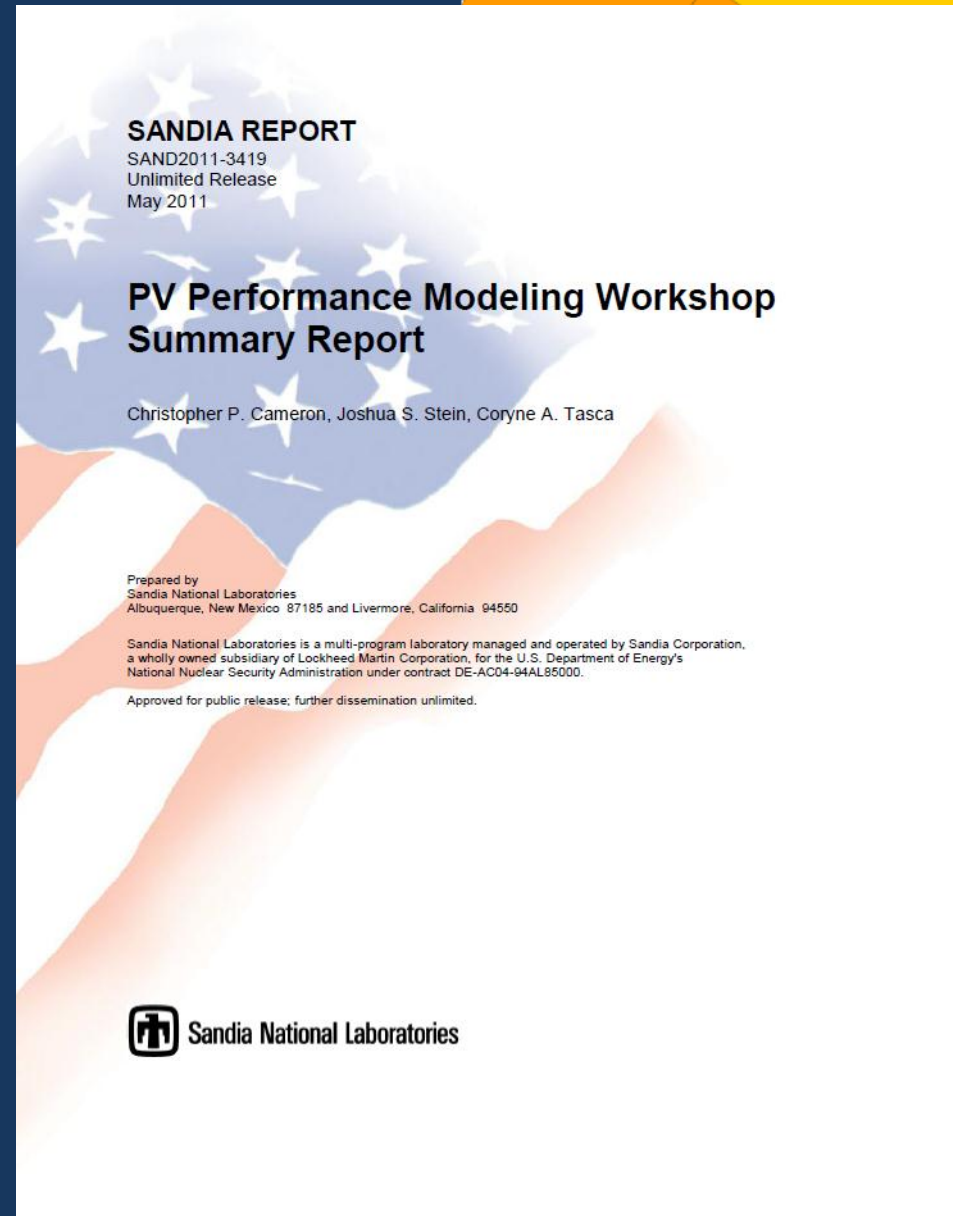
**Presented at the 2013 Sandia PV Performance Modeling Workshop
Santa Clara, CA. May 1-2, 2013**

Published by Sandia National Laboratories with the Permission of the Author

ChrisCameronPV@gmail.com

1st PV Performance Modeling Workshop

- Organized by Sandia
- Held in Albuquerque, September 22-23, 2010
- Plan was for a small invitation-only workshop format
- Interest grew quickly
- Attendance capped at 50 due to space limitations



Objectives of First Workshop

- Review the current state of the art
- Perform an intercomparison
 - Among modeling tools
 - To measured data
- Educate each other about needs, concerns, and possible paths forward
- Determine next steps to improve and validate model accuracy

1st Workshop Participants



Manufacturers

About Solar
BP Solar
First Solar
Miasole
SoloPower
SunPower
Uni-Solar
Yingli

Independent Engineers

BEW Engineering
Black and Veatch
Luminate

Consultants/Analysts/Other

Steve Ransome
Navigant
SolarTech

Integrators

American Capital
Energy
Borrego Solar
Sun Edison

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
Laboratory
Sandia National
Laboratories
US DOE

Meeting Structure



Day 1 morning

- Overview and Needs Assessment from Integrators, Manufacturers, and Independent Engineers
- Analysis of Model Accuracy
 - Results of pre-work

Day 1 afternoon

- Modeling the Module
 - Module models
 - Modeling module temperature
 - Discussion of needs, priorities, and paths forward

Day 2 morning

- Beyond the module – systems modeling
 - System losses
 - Shading and MPPT
 - Large systems
 - Discussion
- Impact of uncertainty
- Discussion on ensuring quality, need for standards, model validation
- Action items and next steps

Day 2 afternoon

- Sandia test facility tours

Pre-Workshop Modeling Assignment

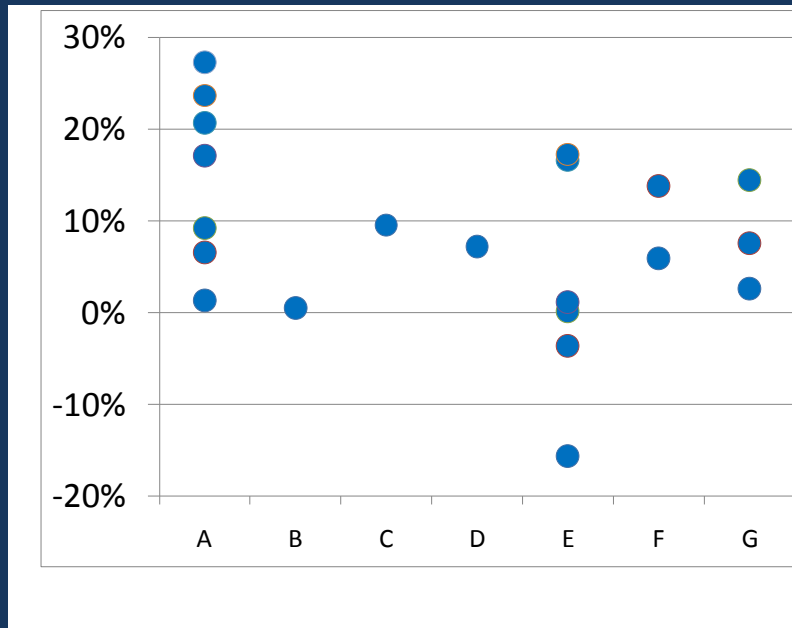
- Participants were sent systems design descriptions and measured weather data in TMY-2 format to analyze with hourly performance model of their choice
- Participants did not receive performance data
- Systems analyzed:
 - 1.4 kW mcSi and 1.1 kW CIS at NREL
 - 1 kW cSi at Sandia →



Results of Exercise

Workshop Exercise

Annual System Output
(Modeled – Measured) ÷ Measured

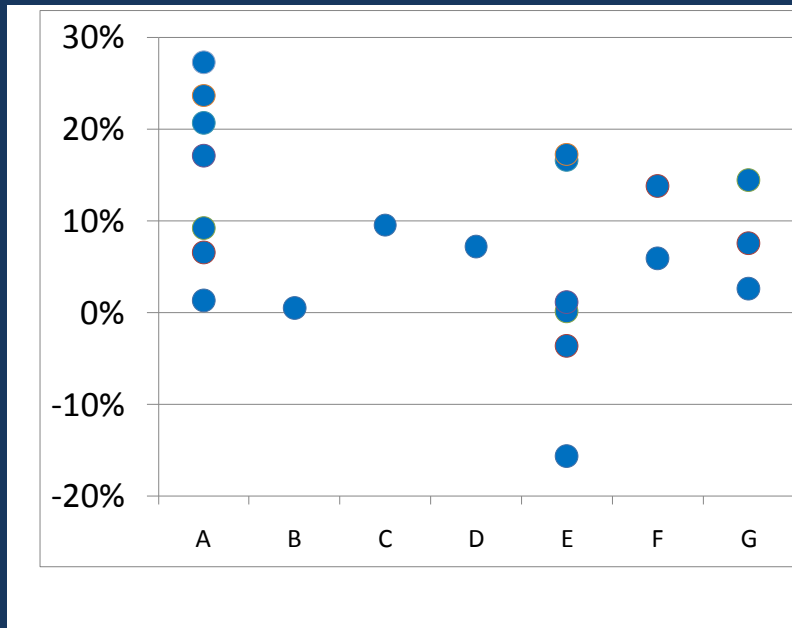


- 21 Data Sets Submitted By Fewer Than 21 Participants
 - Most model developers did not participate
 - Most module manufacturers did not participate
- Illustrates that Model Users Have Many Choices, Including:
 - Inputs, such as module performance coefficients
 - Adjustments and assumptions, such as system loss factors
 - Even Modelers in Same Company Using Same Model (PVsyst) Got Significantly Different Results

Expert Modelers Able to Produce Higher Accuracy

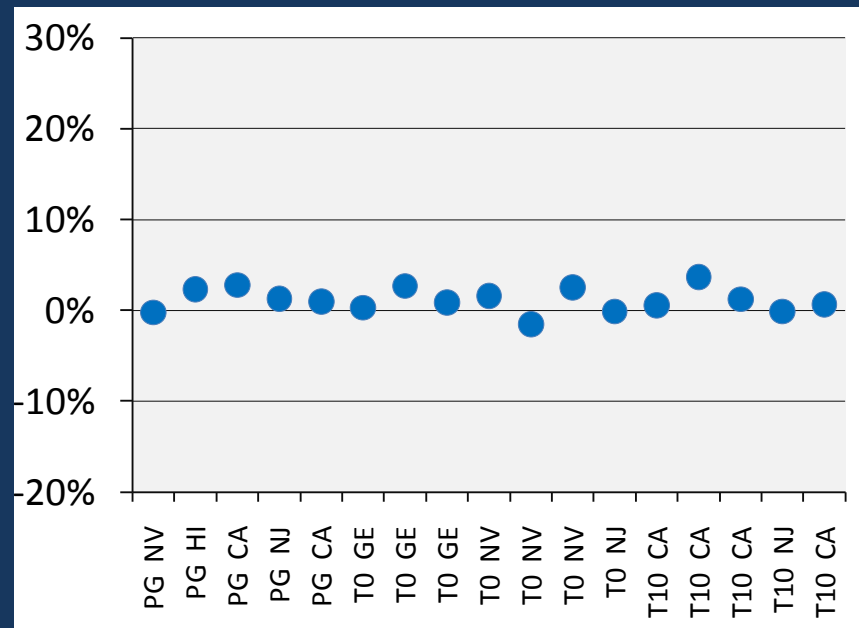
Workshop
Exercise

Annual System Output
(Modeled – Measured) ÷ Measured



Model

From SunPower's Presentation
at the Workshop



System Type and Location

Paths Forward

- Workshop Participants Identified Needs and Priorities in Four Areas:
 - Module data
 - System data
 - Standardized process for model validation
 - Model improvements

Module Data – Accuracy



- Manufacturers Want PV Models To Accurately Differentiate Module Performance, Such As
 - Low-light response
 - Temperature response

Module Data – Source



- 2010 Module Data Sources Vary
 - CEC (6 par): requires STC data from independent labs
 - Sandia model: outdoor tests from SNL or TUV-PTL
 - PVsyst: some manufacturers supply custom coefficients for their modules
- Participants recommendations:
 - Tests should provide data for all models
 - Testing by independent labs
 - Testing of multiple samples of modules
 - Pathway to rapid testing of new technologies
 - Evaluate time variation in module characteristics
 - Beyond overall degradation

System Data



- Model validation and improvement require high quality data sets
- Broader studies needed to characterize system losses
- Lack of public data
 - Integrators that monitor systems do not release data
 - Publicly-owned systems might be sources
 - Performance monitoring companies may be key

Standardized Process for Model Validation

- Workshop participants' recommendations:
 - Development of a standardized process
 - Uncertainty of inputs must be known
 - Become involved in standards writing process

Model Improvements



- Participants identified these needs:
 - Model multiple years using stochastic analysis
 - Most models use only typical year (TMY)
 - Model systems not operating at MPPT
 - Due to shading or multiple orientations
 - Understand potential of power optimizers
 - Ability to accept measured solar resource data
 - Parametric analysis (like SAM)
 - System loss output chart (like PVsyst)
 - Output formats compatible with various financial models