



SUNPOWER™

Sandia PV Modeling Workshop

Ben Bourne, SunPower Corporation

September 22, 2010

Agenda

- Introduction to PVSIM
 - Why SunPower chooses to operate its own simulation tool, despite pushback from customers
- Validation practices
 - SunPower's validation history
 - Importance of using indoor and outdoor measurements for validating database values
 - How accurate is accurate enough?
- Soiling: How to manage the greatest source of uncertainty in key regions
- Need for standards to help guide model acceptance

PVSim: SunPower's Performance Prediction Tool

PVSim V1.1.77 - LOCATION - Microsoft Internet Explorer provided by SunPower Corporation

User: bbourne

Weather Data Location

Location weather data:

NREL Meteornorm Measured

Country: United States

State/Province/region: California

Location: Sacramento

Override elevation: 8 Meters

Date Range

Month: Day:

Start Date: January 1

Save Configurations: Solare_Roma

Site: United States, California, Sacramento

Lat: 38.52° Site

Long: -121.50° Tim

Log Out

RESULTS

CONFIGURATION

Log Out

PVSim V1.1.77 - RESULTS - Microsoft Internet Explorer provided by SunPower Corporation

United States, California, Sacramento - Simulation - 21 September 2010

User: bbourne

Yield (Year 1): 1539.1 kWh/kWp

Performance Ratio (PR): 79.4 %

Capacity Factor (CF): 19.7 %

System Nameplate Rating: 124.2 kWp

Inverter AC Rating: 112.9 kW

PVUSA System Rating: 104.4 kW

Month	Gh Insolation kWh/m ² /day	POA Insolation kWh/m ² /day	AC Energy kWh
Jan	1.87	2.23	7085
Feb	2.96	3.51	10114
Mar	4.25	4.77	15164
Apr	5.90	6.29	19074
May	7.19	7.36	22441
Jun	7.83	7.84	22764
Jul	7.89	7.99	23698
Aug	7.09	7.46	22254
Sep	5.78	6.45	18782
Oct	4.00	4.73	14519
Nov	2.34	2.87	8627
Dec	1.73	2.14	6636
Year: 1	4.91	5.31	191158
Complete Simulation	4.91	5.31	191158

Itemized Annual Energy Losses	Loss (%)
Shading Loss	-0.40
Soiling Loss	-5.00
Angle-of-Incidence Loss	-3.99
Air Mass Adjustment	0.21
Operating Temperature Adjustment	-4.37
Efficiency vs. Irradiance Adjustment	-1.49
Thermal Voltage Adjustment	0.00
Module Flash Adjustment	0.87
Module Mismatch Loss	-1.00
DC Wiring Loss	-1.50
Inverter Efficiency Adjustment	-4.00
Inverter AC-Capacity Clipping Loss	0.00
Transformer Efficiency Loss (Day)	0.00
Transformer Efficiency Loss (Night)	0.00
AC Wiring Loss	0.00
Site Shading Loss	0.00
Auxiliary Load Loss	0.00
Annual Availability	98.00

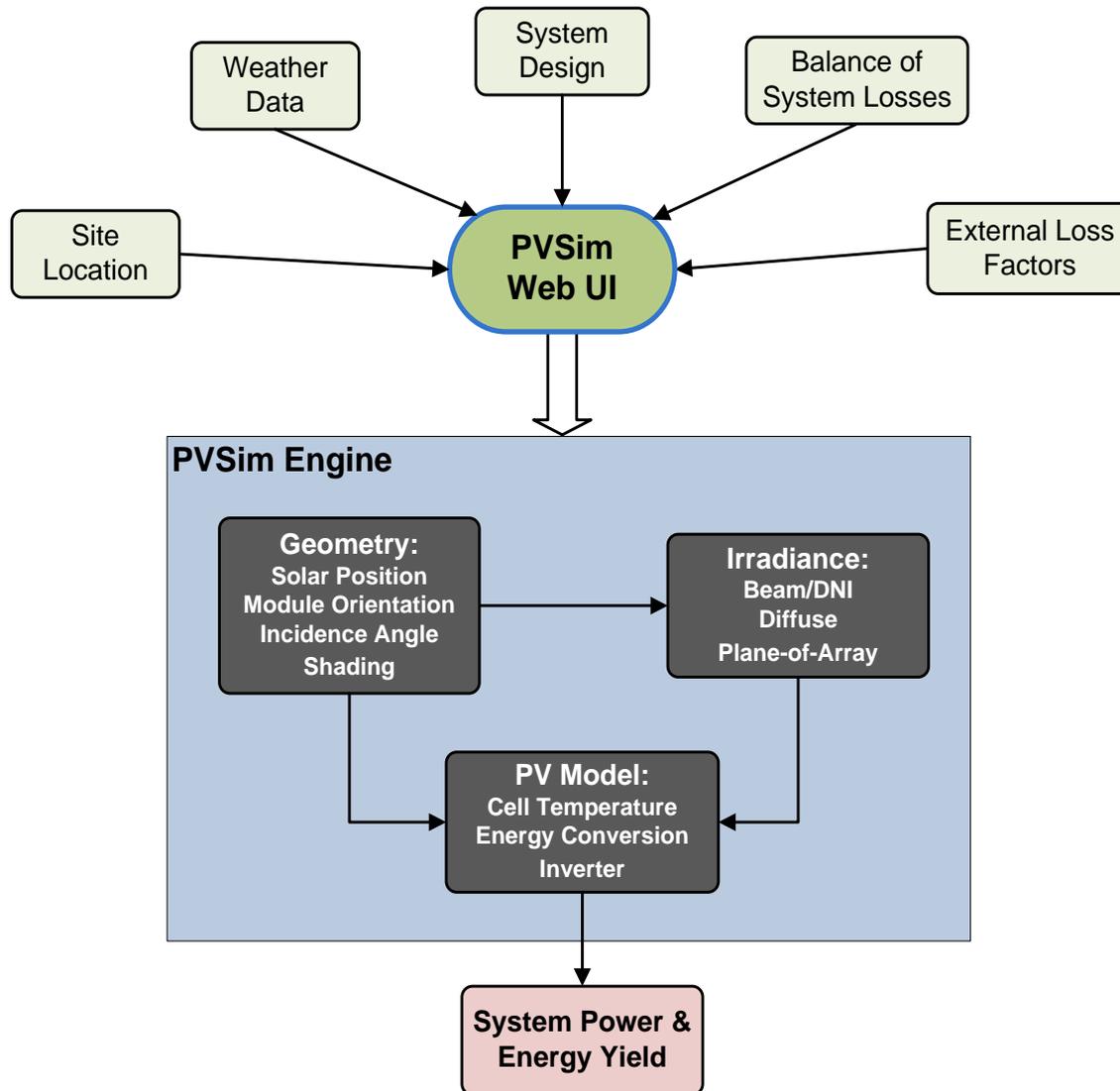
Locale uses Daylight Savings Time (not in Hawaii, Arizona, or Eastern Indiana)

DST begins on: March 9 DST ends on: November 2

Output detail: 1 Save Results ...

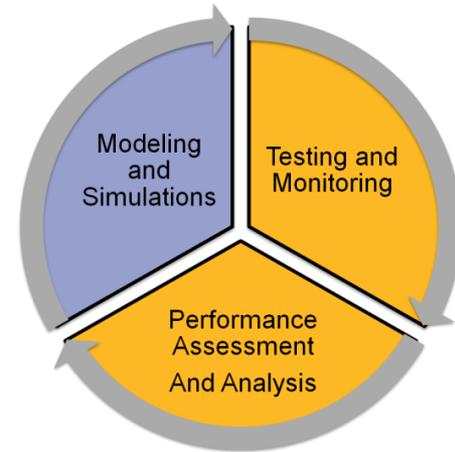
Done Local intranet 100%

PVSim: SunPower's Performance Prediction Tool

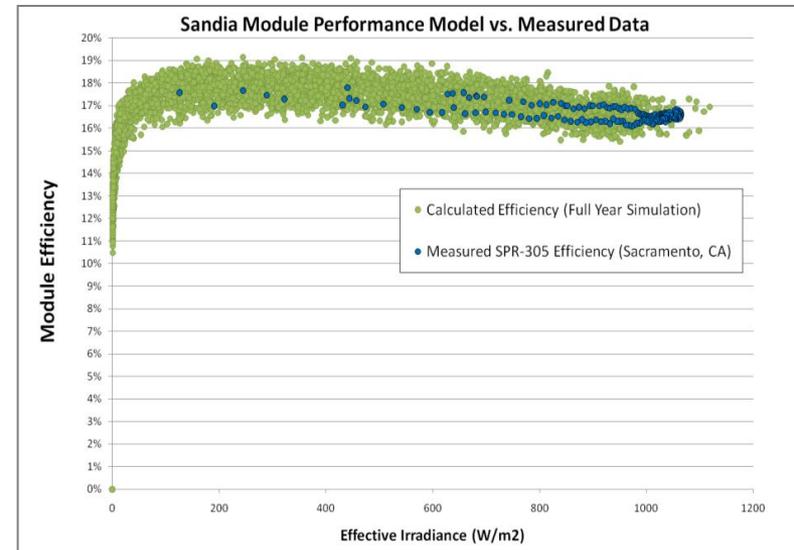
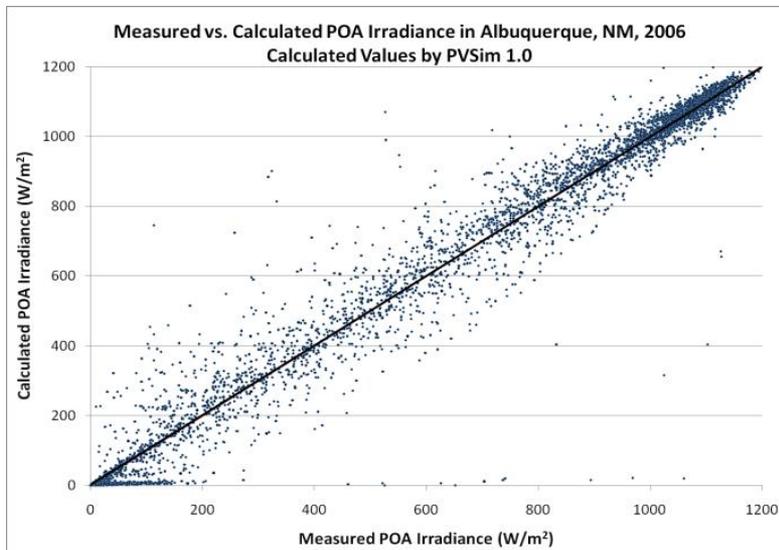
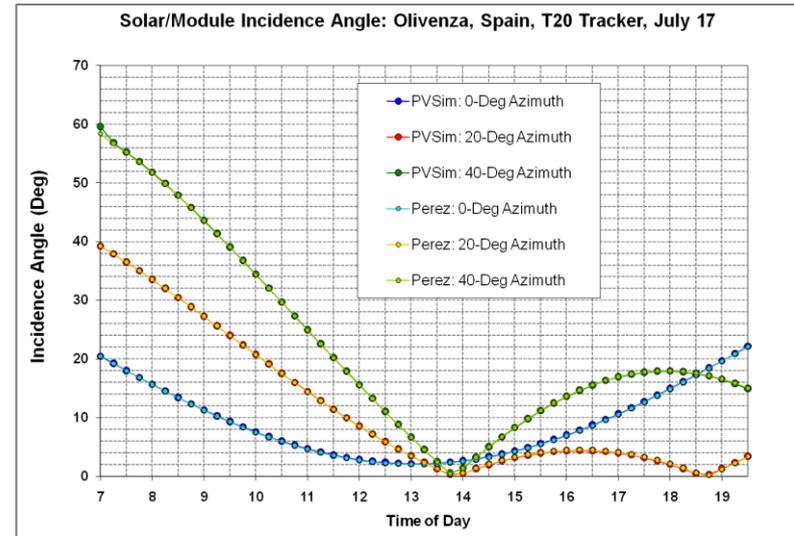
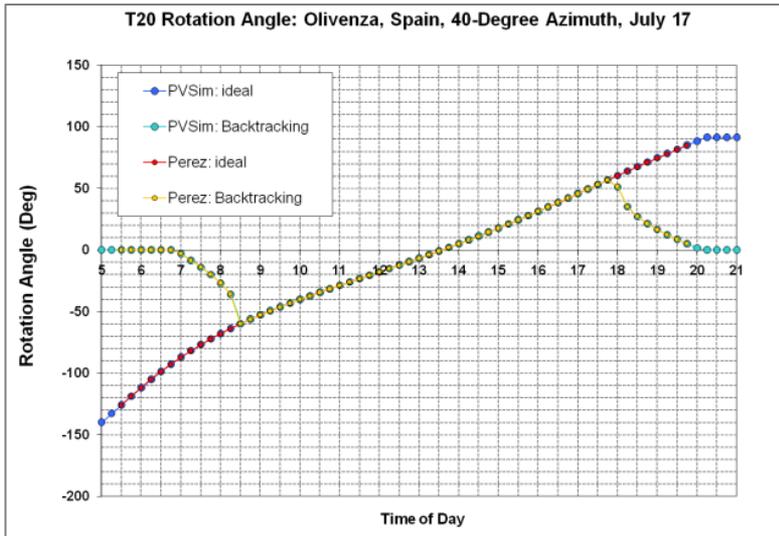


PVSim: Why a Proprietary Simulation Tool?

- SunPower sells energy production systems
 - Customers need to know how much power and energy their system will produce over time
 - SunPower needs to know how to price these systems
- SunPower selects, develops and assembles the best models
 - Most are publicly available models (irradiance, Sandia performance)
 - Some are specific to our proprietary products (tracking, shading)
- PVSim allows us to explicitly model our current, future and conceptual products with a high degree of accuracy
- SunPower has more than 650 installed systems for evaluating the accuracy of PVSim

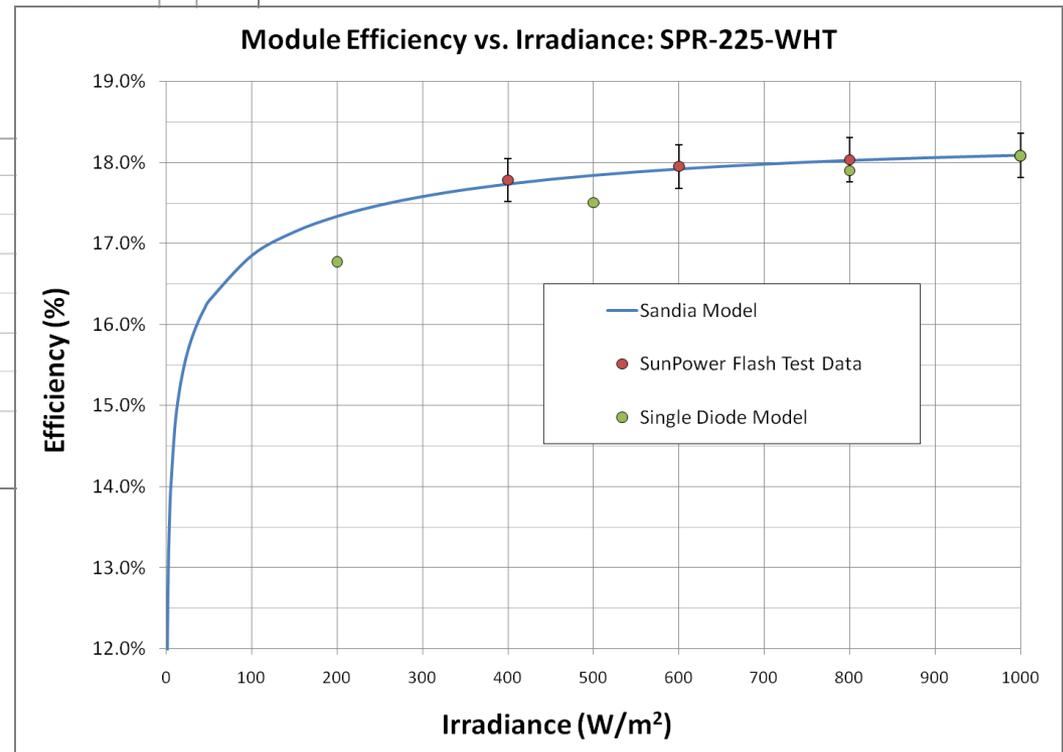
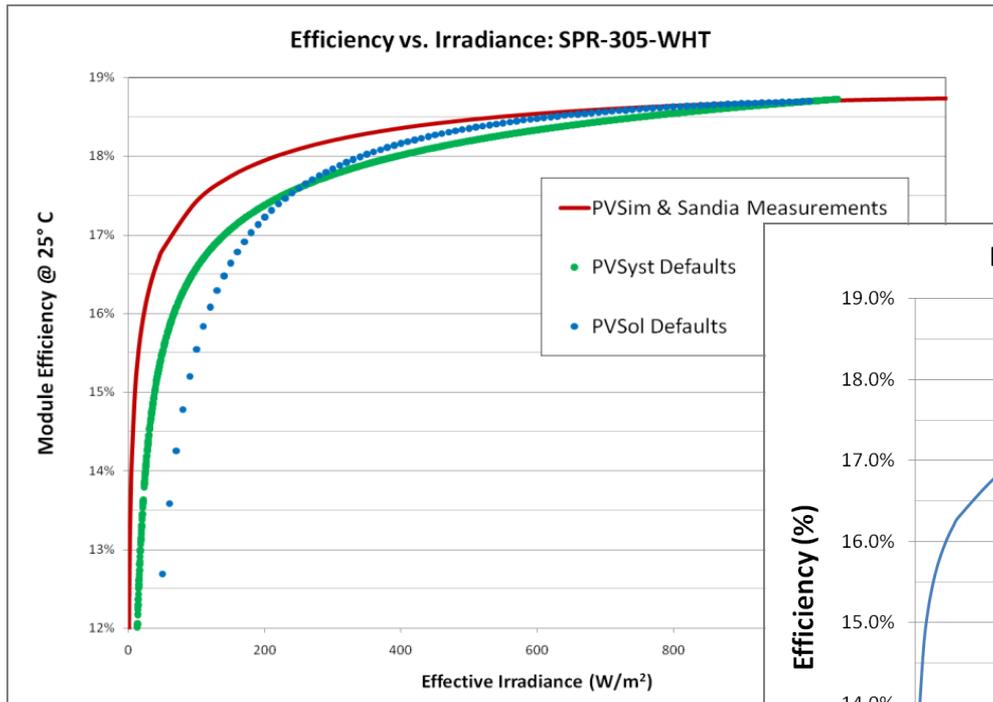


PVSim: Validation Practices



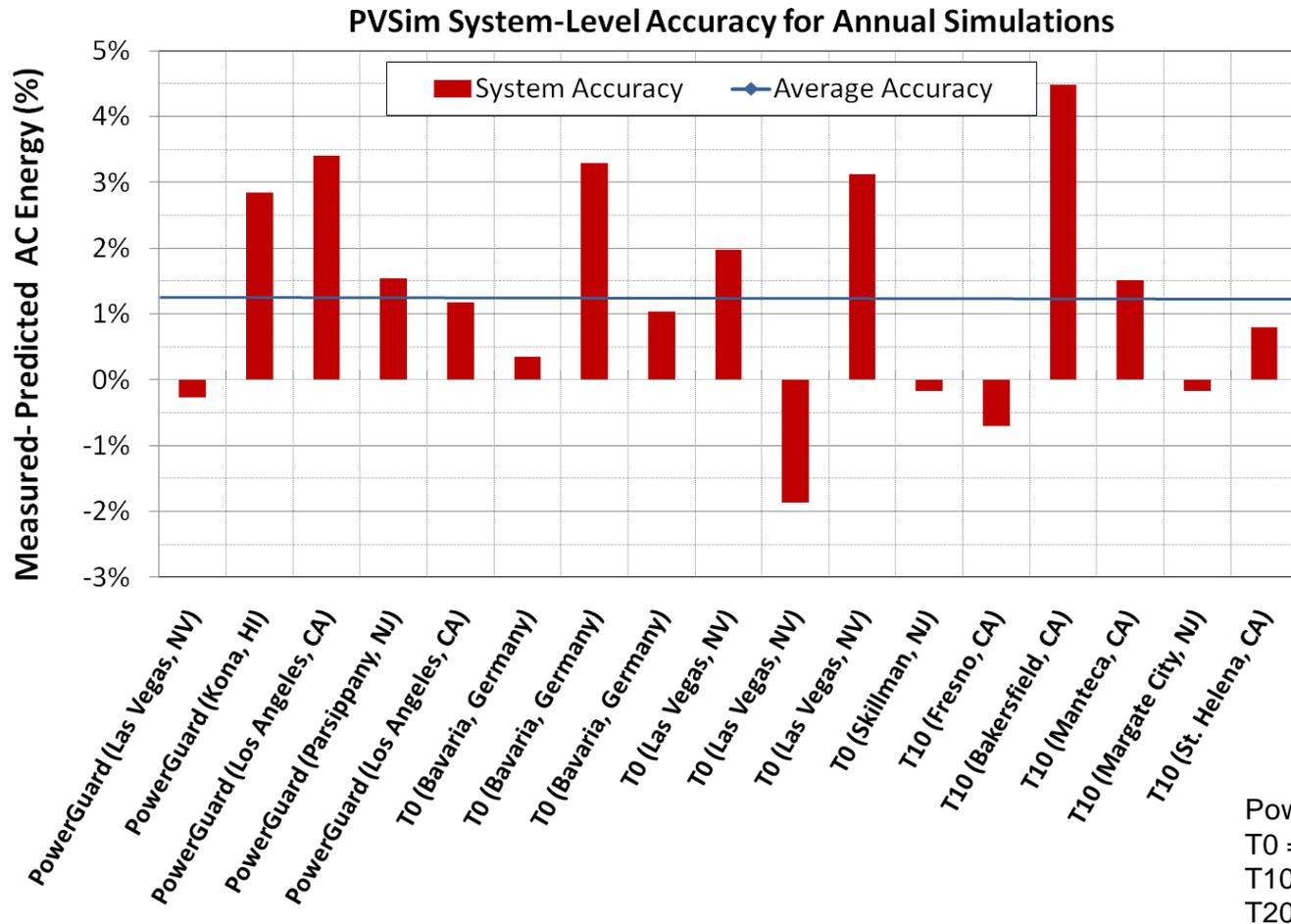
Validation: Indoor and Outdoor Measurements

- Commonly-used models with manufacturers data-sheet values can incorrectly predict modules' response to irradiance and spectral variations



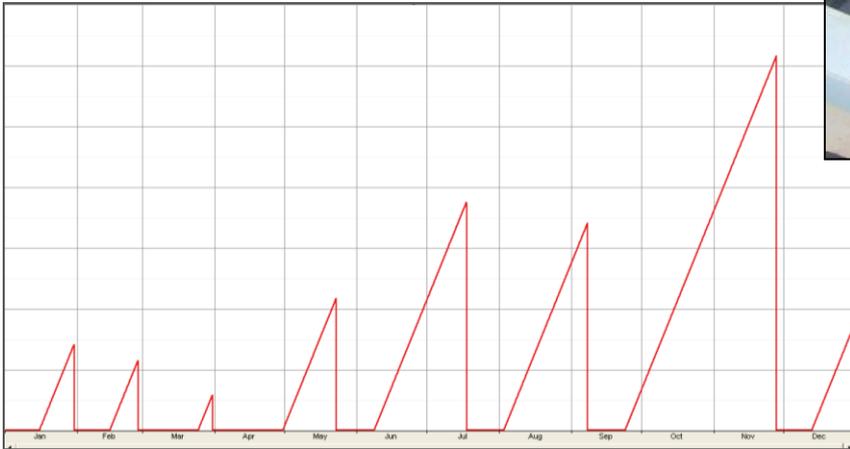
SunPower simulation tool

- PVSim provides accurate prediction across a range of applications. On average, annual energy delivery is 1.2% greater than predicted.



Soiling: the greatest source of uncertainty

- Simple soiling models work well most of the time, but modeling soiling well in all climates and regions is difficult because it is a complex function of
 - Soiling composition
 - Variable rainfall
 - Ambient conditions
 - Surrounding environment
 - Um, migration patterns



Soiling: the greatest source of uncertainty

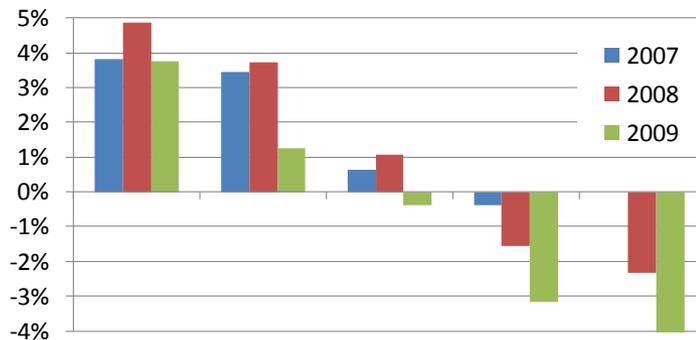
- Some extremely “uncertain” soiling cases



- [A ridiculously uncertain soiling case](#)

Need for Performance & Simulation Standards

- Requirements for validation and model evaluation (this program)
- Reconciliation of the models and the 3rd-party field test data



- Testing standards: quality & audits
- Account for baseline and evolving module ratings
- Clear understanding of the metrics
 - Delivered AC Power
 - Energy
 - Yield (kWh/kWp – with focus on the Wp rating)
 - LCOE (levelized cost of energy)

www.sunpowercorp.com

Thank You