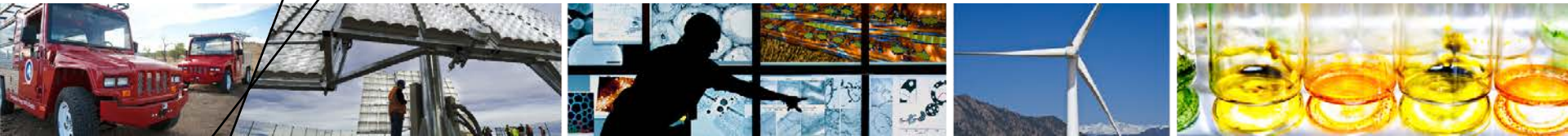


Climatically Diverse Data Set for Flat-Plate PV Module Model Validations



Bill Marion

**2013 Sandia PV Performance Modeling
Workshop
Santa Clara, CA, May 1-2, 2013**

NREL/PR-5200-58600

Background

- **Work began in FY2011 to fulfill a FY2014 milestone for DOE's System Integration Technology Validation Project**
 - “Comprehensive data set, with low measurement uncertainty, of I-V curves and associated meteorological data for PV modules representing all flat-plate technologies and for weather conditions for three climatically different locations completed”.

Intended Data Applications

- **Validation of existing PV module models and/or the development of new models.**
- **Analysis of performance differences from climate.**
- **Data available to the public.**

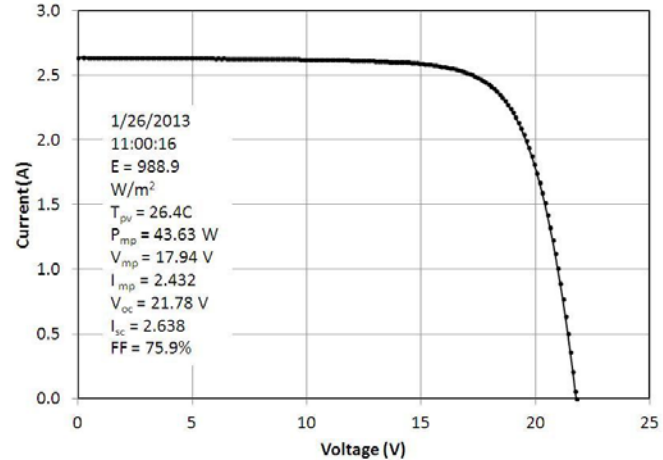
Field Site Locations

- **Cocoa, FL**
 - Florida Solar Energy Center
 - Subtropical climate
 - Jan 2011 – Mar 2012
- **Eugene, OR**
 - University of Oregon
 - Marine west coast climate
 - Dec 2012 – Feb 2014
- **Golden, CO**
 - NREL
 - Semi-arid climate
 - Aug 2012 – Sep 2013



PV Module Technologies Deployed

- single-crystal Si
- multi-crystal Si
- a-Si/x-Si HIT
- CdTe
- CIGS
- a-Si/a-Si and a-Si/a-Si/a-Si
- a-Si/nanocrystalline-Si tandem



Data Measurements

- **PV Module Data**

- I-V curves ever 5 minutes
- Peak-power tracking 5-minute averages
- PV module back-surface temperature



- **Meteorological Data**

- POA irradiance with K&Z CM22 and LI-COR
- Direct normal, diffuse and global horiz. irradiance
- Wind speed and direction; dry bulb temperature; relative humidity; barometric pressure; precipitation

Daily Operations

- **Site**

- Daily maintenance, except weekends and holidays
- One of two identical PV modules cleaned for soiling assessment

- **NREL**

- Data retrieval and archiving
- Daily quality assessment of previous day's data

Daily Quality Assessment

- **Based on ISO 17025 procedures at NREL**
- **Automated checks each day with email notification**
 - Irradiance and other meteorological data
 - PV module temperatures
 - PV performance ratios
 - I-V curves acquired meet minimum and stable irradiance criteria

PV Module Characterization

- **Pre- and post-deployment baseline solar simulator measurements at STC**
- **Post-deployment characterization of each PV module to provide performance coefficients and data for PV models**
 - Sandia performance characterization method
 - IEC 61853 performance matrix
 - 23 I-V curves for a matrix of temperatures and irradiances ranging from 15°C to 75°C for temperatures and 100 W/m² to 1100 W/m² for irradiances

Data Set Content and Format

- **Comma Separated File (csv) for each module**
- **Time stamp of I-V curve**
- **POA irradiance**
 - Immediately before I-V scan, W/m^2 , (CMP22)
 - Change during I-V scan, $\pm\text{W/m}^2$, (both CMP22 and LI-COR)
- **I-V curve characteristic data per ASTM 1036 data fitting procedures**
 - I_{sc} (A), V_{oc} (V), P_{mp} (W), I_{mp} (A), V_{mp} (V), FF
- **I-V curve data pairs, as measured**

Data Set Content and Format (continued)

- **Meteorological Data**

- Precip (mm) – accumulated daily total prior I-V scan
- Ambient temperature ($^{\circ}\text{C}$) – closest 5-sec sample
- Relative humidity (%) – closest 5-sec sample
- Barometric pressure (mb) – closest 5-sec sample

Data Set Content and Format (continued)

- **Solar Data**

- Direct Normal (W/m^2)

- 5-second average containing I-V scan time
 - Standard deviation of 1-sec samples of 5-second average

- Global Horizontal (W/m^2)

- 5-second average containing I-V scan time
 - Standard deviation of 1-sec samples of 5-second average

- Diffuse Horizontal (W/m^2)

- 5-second average containing I-V scan time
 - Standard deviation of 1-sec samples of 5-second average

- Solar QA Residual (W/m^2)

- Direct Normal * $\cos(\text{zenith})$ + Diffuse Horizontal – Global Horizontal

- **Soiling Derate (example: 0.98 = 2% loss due to soiling)**

Questions, Comments, Suggestions

- **PV module characterization?**
- **Data set content or format?**
- **Other?**

bill.marion@nrel.gov