Toward Using PV Reference Cells for Solar Resource (i.e., PV Resource)

Peter Gotseff

Solar Power International 2020
14 September - 27 October 2020
NREL/PO-5D00-77626

INTRODUCTION/ BACKGROUND:

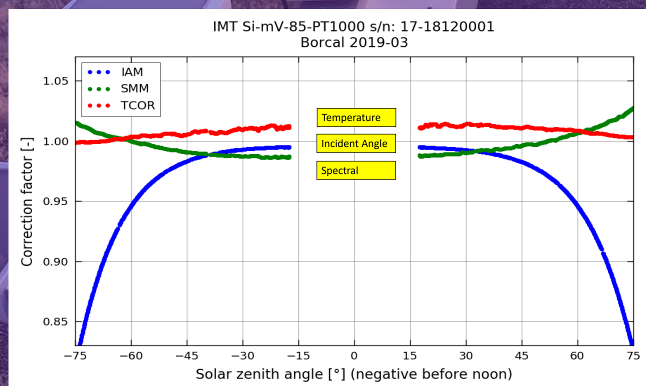
Reference cells measure the equivalent solar resource that is available for photovoltaic (PV) modules. They represent a measurement of the "true" PV resource better than thermopile pyranometers, so their use is often promoted for PV resource assessment. There are several standards (ASTM 1362, IEC 60904-4) that ensure accepted methods of calibration for reference cells but always under normal incidence illumination using the reference spectrum (ASTM G173 or IEC 60904-3) and under standard test conditions. Relative to thermopile pyranometers, however, reference cells can have different spectral, angular, and temperature responses—none of which meet any applicable standard.

This work compares multiple standard calibration methods as well as a new natural sunlight approach applied at the National Renewable Energy Laboratory (NREL) on a sample of commercially available reference cells.

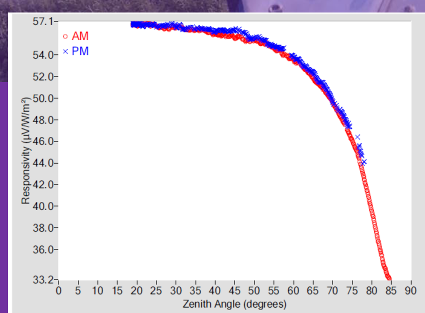
METHODS:

1. In coordination with PV Performance Labs of Freiburg, Germany, NREL calibrated 10 models of reference cells from 6 manufacturers representing 39 separate samples.
2. The responsivity of all cells was determined at NREL's indoor cell calibration lab (Cell Lab), meeting or exceeding IEC60904-1 and ASTM 1362, and using the NREL Broadband Outdoor Radiometer CALibration (BORCAL) method with traceability to SI through the World Radiometric Reference. All BORCAL calibrations are then corrected for spectral differences, angle of incidence, and temperature.

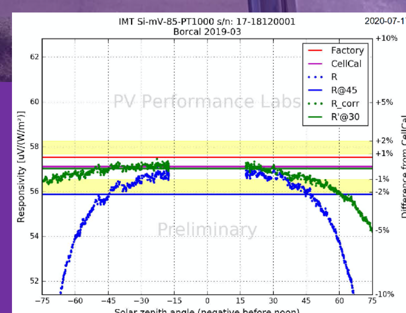
Recent progress has been made in calibrating PV reference cells using an outdoor calibration method that corrects for directional, spectral, and temperature effects.



Correction modifiers



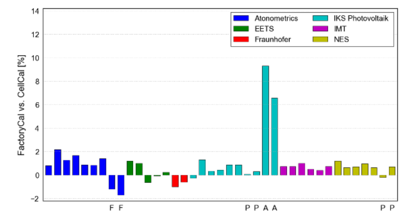
Measured responsivity, R, determined using the BORCAL method



Comparison of responsivities: factory, NREL indoor cell calibration, and outdoor BORCAL responsivities (R, R@45, R_{corr}=f(IAM,SMM,TCOR), R'@30=avg(R_{corr}SZA25-35°)

RESULTS:

- Factory and NREL Cell Lab responsivities compare within 2% of each other with a general bias of +0.8%. The exception was amorphous cell samples, which were greater than 6% (possibly resulting from a spectral mismatch of the factory transfer cell).



- BORCAL calibrations are shown to have a general bias of -2% compared to those of the Cell Lab, but with the spectral mismatch, incidence angle, and temperature correction (example shown in center figure), that bias reduces to -0.5%.
- The angle-of-incidence effects of reference cells is the most import consideration in any deployment application and **must** be corrected for when comparing to pyranometers.

RESOURCES:

For more background on this topic, see:

- A. Habte et al., *Developing a Framework for Reference Cell Standards for PV Resource Applications* (NREL/TP-5D00-72599) (Golden, CO: National Renewable Energy Laboratory, 2018), https://www.nrel.gov/docs/fy19osti/72599.pdf.
- A. Driesse et al., "Investigation of Reference Cell and Photodiode Calibrations under Different Conditions," presented at the 2016 PVSEC.
- A. Driesse et al., "Indoor and Outdoor Evaluation of Global Irradiance Sensors," presented at the 31st European Photovoltaic Solar Energy Conference, Hamburg, Germany (2015).
- International Electrotechnical Commission (IEC), *IEC 60904-4: 2016: Photovoltaic Devices—Part 4: Reference Solar Devices: Procedures for Establishing Calibration Traceability* (Geneva, Switzerland, 2016).
- ASTM, *G167-15: Standard Test Method for Calibration of a Pyranometer Using a Pyrheliometer* (West Conshohocken, PA, 2015).
- International Organisation for Standardization (ISO), *ISO 9846:1993:Solar Energy—Calibration of a Pyranometer Using a Reference Pyrheliometer* (Geneva, Switzerland, 1993).

ACKNOWLEDGMENTS:

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.