

## PV Module Reliability Research



**Scope.** PV Reliability studies real-time and accelerated aging of PV modules to help reduce the cost and increase market penetration of photovoltaic systems. As new, lower cost technologies are developed, it is essential to quickly identify whether these products will have adequate lifetimes.

### Core Competencies and Capabilities

**Real-Time Reliability Studies** – Long-term performance, reliability, and failures of PV components and systems are studied at NREL and through collaborations elsewhere. Analysis quantifies long-term degradation and results are shared with the community.

**Accelerated Testing** – PV components and materials are subjected to thermal cycling, heat, moisture, UV, etc. to provide early indication of potential failure modes. New accelerated test and diagnostic techniques are developed to meet specific needs, especially those associated with understanding new devices and materials.

**Regional Test Centers** – In partnership with Sandia National Laboratories, NREL provides validation of new PV technologies. For more information about the test centers, see <http://pvrtc.org/>. To apply for these technical services, see [http://www1.eere.energy.gov/solar/sunshot/financial\\_opps\\_detail.html?sol\\_id=488](http://www1.eere.energy.gov/solar/sunshot/financial_opps_detail.html?sol_id=488).

**Industry Workshop and Standards Support** – Each year, an industry workshop is conducted to encourage exchange of information about PV Reliability: <http://www.nrel.gov/pv/pvmrw.html>

**International PV QA Standards** This project is defining quality assurance standards that can differentiate PV products according to their durability in various climates and will also create a guideline for how to ensure that the manufacturing is completed with consistent quality. For more information: [www.nrel.gov/ce/ipvmaq\\_task\\_force/index.cfm](http://www.nrel.gov/ce/ipvmaq_task_force/index.cfm)

Recent publications can be found at [http://www.nrel.gov/pv/performance\\_reliability/publications.html](http://www.nrel.gov/pv/performance_reliability/publications.html):

#### PV outdoor studies

- Jordan DC, Wohlgemuth JH, Kurtz SR, in Technology and Climate Trends in PV Module Degradation, 27<sup>th</sup> Eur. PVSEC, Frankfurt, Germany, 2012.
- Marion B, in Influence of Atmospheric Variations on Photovoltaic Performance and Modeling Their Effects for Days with Clear Skies, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.
- Meydbray J, Emery K, Kurtz S, Pyranometers, reference cells: The difference, *PV Magazine*, 2012(April).
- Muller M, Marion B, Rodriguez J, in Evaluating the IEC 61215 Ed. 3 NMOT Procedure Against the Existing NOCT Procedure with PV Modules in a Side-by-Side Configuration, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.

#### Accelerated testing and failure analysis

- Bosco N, Silverman T, Kurtz S, Modeling Thermal Fatigue in CPV Cell Assemblies, *J. Photovoltaics*, 2011; 1(2): 242-247.
- Bosco NS, Silverman TJ, Kurtz SR, in On the Effect of Ramp Rate in Damage Accumulation of the CPV Die-Attach, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.
- Bosco, N., Sweet, C., Ludowise, M., Kurtz, S. "An Infant Mortality Study of III-V Multijunction Concentrator Cells," *J. Photovoltaics* (2012).
- Hacke P, Smith R, Terwilliger K, Glick S, Jordan D, Johnston S, Kempe M, Kurtz S, in Testing and Analysis for Lifetime Prediction of Crystalline Silicon PV Modules Undergoing Degradation by System Voltage Stress, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.
- Kempe MD, Kurtz S, Wohlgemuth J, Miller D, Reese MO, Dameron AA, in Modeling of Damp Heat Testing Relative to Outdoor Exposure, PVSEC-21: 21<sup>st</sup> International PVSEC, Yokohama, Japan, 2011.
- Wohlgemuth JH, Kurtz SR, in How Can We Make PV Modules Safer?, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.

#### Power electronics

- Deline C, Meydbray J, Donovan M, Forrest J, in Partial Shade Evaluation of Distributed Power Electronics for Photovoltaic Systems, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.
- Deline C, Meydbray J, Donovan M, Forrest J, "Photovoltaic Shading Testbed for Module-Level Power Electronics," NREL Report No. TP-5200-54876 (2012).
- MacAlpine S, Deline C, Erickson R, Brandemuehl M, in Module mismatch loss and recoverable power in unshaded PV installations, 38<sup>th</sup> PV Specialists Conference, Austin, TX, 2012.

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