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# PV Module Reliability R&D Project Overview

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R.L. Hulstrom

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# PV Module Reliability R&D Project Overview

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## ABSTRACT

The DOE Solar Energy Technologies Program includes a sub-key activity entitled "Photovoltaic Module Reliability R&D." This activity has been in existence for several years to help ensure that the PV technologies that advance to the commercial module stage have acceptable service lifetimes and annual performance degradation rates. The long-term (2020) goal, as stated in the *Solar Program Multi-Year Technical Plan*[1], is to assist industry with the development of PV systems that have 30-year service lifetimes and 1% annual performance degradation rates. The corresponding module service lifetimes and annual performance degradation rate would have to be 30 years lifetime and approximately 0.5% (or less, depending on the type of PV system) annual performance degradation. Reaching this goal is critical to achieving the PV technology *Levelized Energy Cost Targets*, as listed and described in the *Solar Program Multi-Year Technical Plan*.

This paper is an overview of the Module Reliability R&D sub-key activity. More details and the major results and accomplishments are covered in the papers presented in the PV Module Reliability Session of the DOE Solar Energy Technology Review Meeting, October 25-28, 2004, in Denver, Colorado.

## 1. Objectives

Our long-term goal is to work with the U.S. photovoltaics module manufacturers to optimize the time and funding required to advance module technologies from the prototype stage to the commercial manufacturing stage, with respect to meeting acceptable performance and reliability requirements. As stated above, the *Solar Program Multi-Year Technical Plan* has a 2020 objective of PV systems having a 30-year service lifetime and an annual performance degradation rate of 1%.

The supporting objectives are as follows:

- To quickly isolate, scientifically understand, and help industry mitigate module failure and/or degradation mechanisms
- To gather and analyze outdoor, long-term exposure data for all candidate modules
- To utilize selected indoor and outdoor accelerated exposure testing to discover and/or replicate observed outdoor failures and performance degradation
- To develop new and improved module packaging designs that result in improved service lifetimes and annual performance degradation
- To assist industry with developing new consensus standards and codes for module performance and/or qualification testing
- To characterize and provide models for PV module performance and reliability.

## 2. Technical Approach

PV Module Reliability R&D is an integral element of the DOE Solar Energy Technologies Program's system driven approach (SDA). The SDA is described in more detail within the FY04 Solar Program Annual Report. Figure 1 is an illustration of the SDA, along with the Key Activities (Fundamental Research, Advanced Materials & Devices, and Technology Deployment) of the PV Subprogram. As can be seen, Module Reliability R&D is part of Advanced Materials & Devices, along with Thin Film Partnerships and Advanced Manufacturing R&D. The Module Reliability R&D includes portions of Materials Research and Components R&D, and is supportive of and closely coordinated with the module development and manufacturing efforts conducted under the Thin Film Partnerships and Advanced Manufacturing R&D projects. Plus, the Module Reliability R&D is closely integrated with the Systems Engineering and Reliability effort.

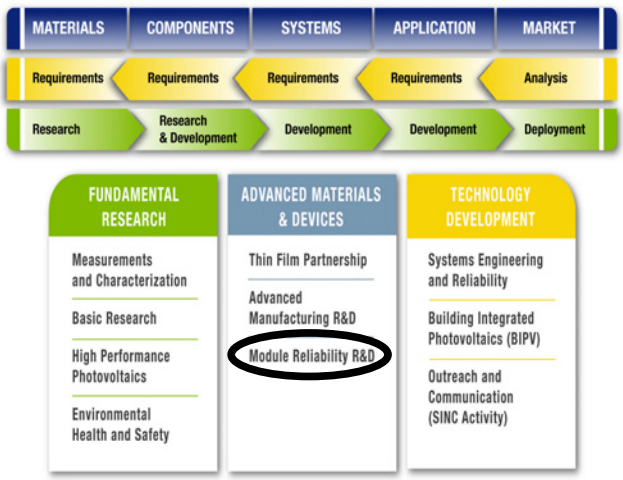


Fig. 1: Systems-Driven Approach and Module Reliability R&D.

The technical approach includes: 1) accelerated indoor and outdoor, as well as long-term outdoor exposure testing; 2) advanced diagnostics; 3) failure and degradation discovery, identification, analysis, and mitigation; 4)characterization and modeling; and, 5)module packaging and design R&D.

This effort is conducted as team effort including the National Renewable Energy Laboratory, Sandia National Laboratory, the Florida Solar Energy Center, the Southwest Technology Development Institute, Arizona State University, and many PV industry partners.

**3. Results and Accomplishments**

Detailed results and accomplishments are presented in the following papers.

- Performance Degradation Rates in Commercial Modules. D. King, Sandia Labs.
- Outdoor Monitoring and High Voltage Bias Testing of Thin Film PV Modules. N. Dhere, FSEC.
- Module Design, Materials, and Packaging Research Team. T. McMahon, NREL.
- Packaging Materials and Design for Improved Module Reliability. G. Jorgensen, NREL.
- Module Encapsulation Diagnostics and Modeling. M. Kempe, NREL.
- Alternative Approaches to Bus Bars for PV Modules. J. Pankow, NREL.
- NREL PV Module Reliability and Performance R&D; Status and Accomplishments. C. Osterwald, NREL.
- Advanced Indoor Module Light-Soaking Facility. J. DelCueto, NREL.
- Outdoor Energy Rating Measurements of PV Modules. Y. Tang, Arizona State University.
- PV Module Durability Research and Module Long-Term Exposure. N. Dhere, FSEC.

**4. Conclusions**

The DOE Solar Energy Technologies Program's systems driven approach is used as an approach to relate and integrate R&D activities spanning the scope from materials research to market analysis and deployment. This paper has shown how the PV Module Reliability R&D sub-key activity fits within the overall systems driven approach, the other sub-key activities, and the key activities of the PV Subprogram.

**REFERENCES**

[1] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solar Energy Technologies Program Multi-Year Technical Plan, 2004, Washington, DC,* pp. 128.

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