Solar America Board for Codes and Standards

A Literature Review and Analysis on Accelerated Lifetime Testing of Photovoltaic Modules

Prepared by

(Mani) GovindaSamy TamizhMani
Joseph Kuitche
Photovoltaic Reliability Laboratory
Arizona State University

www.solarabcs.org

ACCELERATED LIFETIME TESTING OF PHOTOVOLTAIC MODULES

Report Overview

This report provides a literature review and associated analysis of photovoltaic (PV) field failures, degradation mechanisms and statistics, and available accelerated testing (AT) methodologies. To generate this report, the authors collected and systematically analyzed the major sources of literature on PV module reliability and durability. The report covers:

- the difference between reliability and durability;
- common failure and degradation modes and mechanisms of PV modules;
- accelerated stress types (including potential induced degradation), levels, and prioritization;
- pitfalls in preparing representative sample designs for accelerated stress testing;
- existing and planned (potential) accelerated comparative and lifetime testing programs;
- key attributes of accelerated comparative and lifetime testing programs;
- considerations for designing and developing new accelerated comparative and lifetime testing programs;
- discussion of a possible approach for a PV rating system; and
- physical and statistical models for lifetime prediction using black-box and white-box approaches based on field degradation data and accelerated test data.

Why the Report is Important

The anticipated lifetime of PV modules spans several decades, and construction materials and design are constantly changing in an effort to reach the module power price of $0.5 per watt and to reduce the levelized cost of energy to about 6 to 8 cents per kilowatt-hour. More than 94% of installed modules around the world were manufactured within the last five years and may incorporate new construction materials. Stakeholders cannot wait for decades to identify the failure modes and mechanisms of these new modules. The purpose of AT is to assess the reliability and durability of products by inducing failures and degradation in a short period of time using accelerated test conditions much more severe than actual field operating conditions while replicating the actual field failure mechanisms. This report communicates and emphasizes the importance of AT for assessing the reliability (failures) and durability (degradation) issues related to the lifetime of PV modules in the field.

Issues

Technology risk—the concern that a technology will underperform (durability) or become obsolete prematurely (reliability)—is one of the major barriers to PV deployment and project financing. Climate-specific and technology-dependent durability and reliability are the primary determinants of PV module lifetimes.

Maximizing energy production and minimizing downtime results in the highest return on investment for PV systems, making the technology attractive to investors and consumers. Improving durability (minimizing soft or degradative losses) maximizes energy production while improving reliability (minimizing hard or catastrophic failures) minimizes downtime.

The manufacturer's warranty period typically exceeds 20 years for crystalline silicon modules and 15 years for thin-film modules. Unfortunately, there is little credible field data or independently conducted accelerated test data available to support many of these lengthy warranty periods at the same time that investors, financiers, power purchasing agreement companies, and consumers require objective substantiations of such claims.

Key Findings

This report includes the following observations about the state of current and future AT for PV modules:

- Much of the information needed to develop accelerated testing protocols for comparative and lifetime testing of PV modules is available from a number of sources. These protocols can be developed through an international effort along with data sharing support from the industry. These protocols could then be converted into national or international test standards by one or more standards developing organizations.
- The design, packaging, and construction of PV modules as well as the field environment in which they operate all contribute to their failure and degradation modes and mechanisms.
- There is a great need to develop a database of climate-specific technology-sensitive wear-out failures in old (10 to 30 years) PV modules that have similar or identical construction characteristics to those of current generation modules. Based on this wear-out failure database, a set of accelerated tests could be developed and prioritized for each climate-specific condition.
- In the absence of detailed physical or statistical modeling reported in the public literature, this report presents background as well as a detailed analysis of the physical and statistical models relevant to PV modules.
- There is a need for the development of a climate-specific, technology-agnostic comparative rating system and lifetime rating system. Consumers and investors are anxious to have a usable rating system right now at least for crystalline silicon technology, which represents more than 80% of the world market. This can be implemented for crystalline silicon technology while gathering statistically significant reliability and durability data from the field for thin-film technologies.

For more information please contact:

Mr. Larry Sherwood, 303-413-8028,
larry@sherwoodassociates.com.

Download the full report:

www.solarabcs.org/acceleratedtesting

About Solar America Board for Codes and Standards

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate widespread adoption of safe, reliable, and cost-effective solar technologies.

For more information, visit the Solar ABCs website:
www.solarabcs.org

Solar America Board for Codes and Standards

www.solarabcs.org