Sandia National Laboratories

Energy, Climate & Infrastructure Security

Photovoltaic Systems Evaluation Laboratory (PSEL)

PSEL is a multi-user, multi-sponsor facility that conducts research in photovoltaic (PV) cells and modules and performs detailed analysis in PV systems design and characterization. PSEL research is conducted on behalf of the U.S. Department of Energy, the U.S. Department of Defense, and other customers, often in collaboration with industry and academic partners.

Vision

To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

Flexibility in Testing Configurations

The PSEL's infrastructure addresses critical issues of PV reliability and power availability. The lab offers four different load configuration capabilities, combining various levels of system amps, volts, and watts, and both indoor and outdoor testing and calibration facilities where laboratory-controlled experiments can be conducted with a wide variety of realistic PV systems scenarios.

Expertise, Knowledge, and Partnerships

PSEL's systems-level approach provides expertise and testing support for existing and new PV designs and emerging technologies. In addition to acting as a high-accuracy PV module and cell testing facility, PSEL analyzes and characterizes performance of PV systems and components, including reference devices, power production modules, power processing inverters, and balance of system hardware.

PSEL leverages Sandia's long history of expertise in a wide range of fundamental science areas, lab diagnostics, and reliability. The lab's research is enhanced by staff expertise in qualitative and quantitative analysis, modeling, root-cause analysis, and PV cell and module characterization. PSEL also has a demonstrated history of appropriately handling proprietary data and offers a strong system for supporting organizations outside of Sandia through technology transfer and standards development.

Research conducted at PSEL accelerates the development and adoption of new and emerging PV technologies by providing highly accurate, comprehensive performance characterization of cells, modules, arrays, and balance of system components in real-world scenarios. Research experts at PSEL team with Sandia's other research experts in the Distributed Energy Technologies Laboratory and the National Solar Thermal Test Facility to advance the reliability, interconnectivity, and availability of solar technologies in the nation's electricity grid.

PSEL Equipment and Capabilities

The PSEL is located at the main Sandia campus in Albuquerque, New Mexico. The site's location provides more than 300 days of sun per year with predominantly clear-sky testing conditions and a spectral variation of less than three percent.

The primary testing tracker, with multiple PV modules, at Sandia's Photovoltaic Systems Evaluation Laboratory.

U.S. DEPARTMENT OF ENERGY

PSEL's equipment includes a 2-axis outdoor tracker capable of testing multiple modules at a high level of precision. In addition to standard reliability and availability testing, outdoor calibrations include irradiance, pyranometer, NIP, and reference cell measurements. The software that guides PSEL's outdoor module tracking system uses date, latitude, altitude, and time of day to ensure optimal angles.

Outdoor testing at PSEL is augmented by on-site weather and irradiance data collection. PSEL researchers use an advanced Climatronics weather system, which includes an aspirated shield for dew point and ambient temperatures, a wind boom and rain bucket, and an applicable pressure gauge.

PSEL Application Areas

Real-time Reliability Studies

Enabling advancement and understanding of PV and emerging technologies through

- High-accuracy indoor and outdoor testing of PV cells, full-size modules, and systems
- Variable voltage/current/power configuration capabilities
- Ability to measure and analyze PV performance under clear and cloudy sky conditions
- Measurement of real-time degradation rates of small-scale PV systems
- On-site measurement of power ratings, system energy yield, performance ratios, and reliability over time

Accelerated and Diagnostic Testing

Providing opportunities to reduce Levelized Cost of Energy and O&M through

- Observation of failure and degradation at the component and materials level, i.e., conductive foil tape and TCO degradation
- Use of Failure Modes and Effects Analysis and Fault Tree Analysis to choose candidates for accelerated lifetime testing (ALT)
- Analysis of failure statistics and mechanisms to develop improved ALT and qualitative testing
- Laboratory-controlled ALT using a variety of tools, including infrared imaging, UV illumination, electro-luminescence, and IV

Predictive Model Development

Combining Sandia's expertise in modeling with extensive types of data, including

- Ability to test individual solar cells and modules and full PV system interactions simultaneously or in various configurations
- Predictions for any component and any level of a PV system for reliability vs time, availability vs time, and field degradation vs time (PVRAM Model)
- Use of on-site weather and irradiance data to evaluate and model environmental effects
- Sensitivity analysis to model potential trade-offs in design and O&M

Mitigation and Failure Analysis

Translating laboratory results and analysis to practical solutions for mitigating field failures through

- Field and lab-controlled O&M and failure data
- Experience in testing effects of delamination, coatings, encapsulants, polymers, and module packaging on reliability
- Ability to conduct root-cause analysis and identify single-cell failures in PV strings
- Analysis of thermal performance, leading to development of module-level temperature coefficients.

Industry Outreach and Standards

Utilizing more than 20 years of technical expertise to support product advancement and the development of standards to

- Develop new procedures for performance and reliability testing, and establish metrics for standards development
- Provide consistent feedback to stakeholders to assist with product and O&M improvements, design optimization, failure mitigation, and safety
- Analyze PV system components and configurations to comply with new and existing codes and standards
- Partner with industry through technology transfer and information-sharing
- Integrate and test emerging technologies, including CPV, thin films, and advanced inverters

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