

## Detailed Meteorological Data Collection

All test sites have comprehensive meteorological data collection:

- different sensor types for solar irradiation (pyranometers, reference cells)
- separation by irradiation type (direct, diffuse)
- different orientations (horizontal, inclined towards south, tracking)
- spectroradiometers, cloud cameras
- air temperature, pressure, humidity
- wind speed and direction
- pollution levels on surfaces

## Further Offers at the Outdoor Performance Test Site in Merdingen

- analyses of the electricity and agricultural yield of agrivoltaic (APV) systems.
- characterization of concentrating PV modules (CPV)
- measurements on inverters and PV battery systems
- qualification of tracked PV systems
- measurements on integrated PV installations, e.g., on noise barriers

## Further Information



Website »Outdoor Performance Lab«  
[ise.link/outdoor-performance-lab](http://ise.link/outdoor-performance-lab)



*Scanning acoustic microscopy (SAM) as a non-destructive method for the investigation of failures and defects of full-size PV modules.*

*Cover image: Visualization of the outdoor performance test site in Merdingen. Graphic: Fraunhofer ISE / Link3D.*

*Alle images: © Fraunhofer ISE*

## Contact

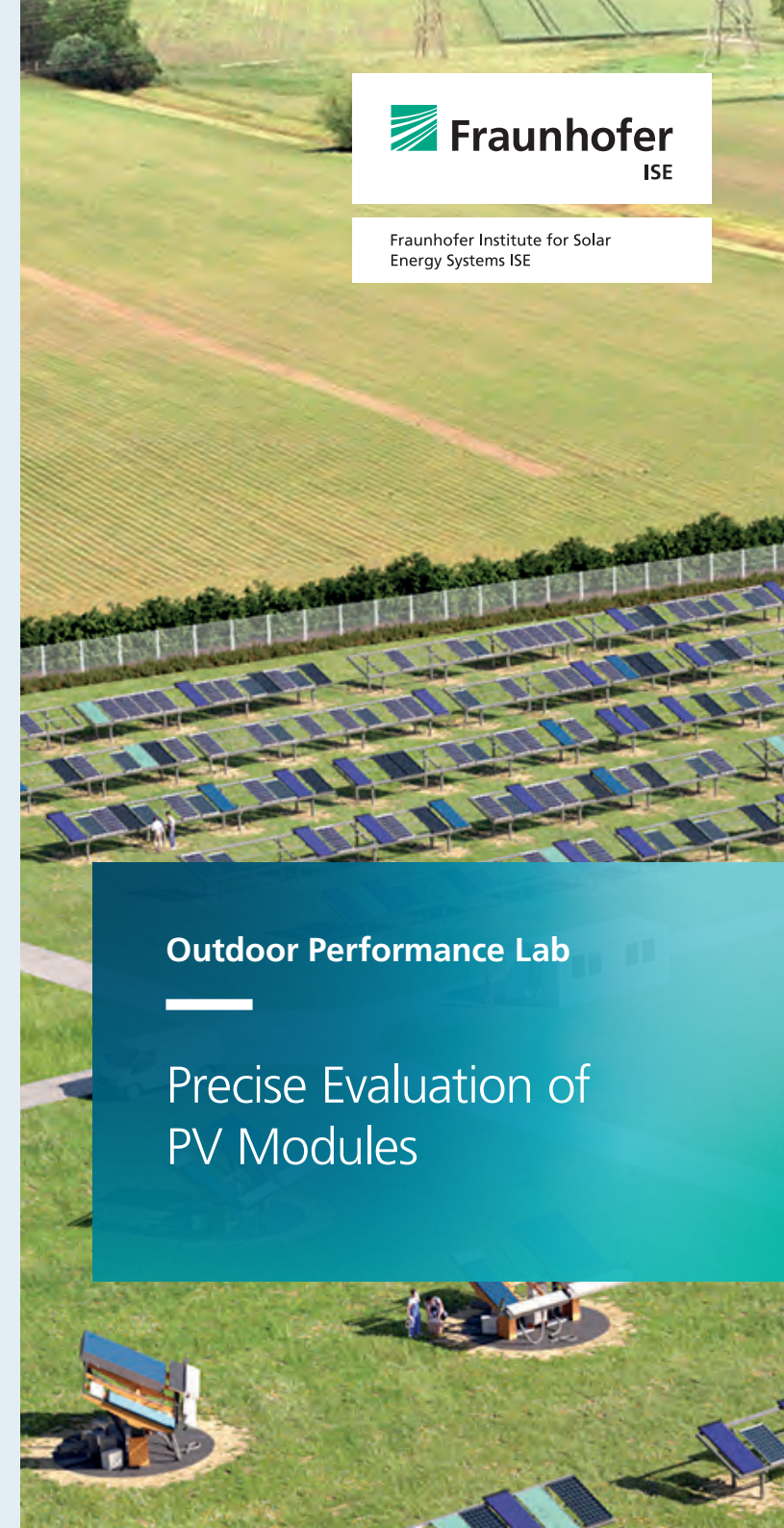
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05-223220-23

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**Outdoor Performance Lab**

**Precise Evaluation of  
PV Modules**

# Precise Evaluation of PV Modules

Reliable measurement data are essential for determining the performance of PV modules.

Fraunhofer ISE's solar test sites enable precise collection of all relevant monitoring data. Together with classical laboratory tests, they provide valuable information on the possible degradation and the expected lifetime yield of PV modules in different climatic zones and allow their comparative evaluation.

## Our Services for Module Manufacturers, Operators, Investors, Banks and Insurance Companies

- initial comprehensive module characterization in the laboratory
- fixed, single-axis or dual-axis tracking module installation
- high-frequency, precise recording of module power, current-voltage characteristics, meteorological data and other operating parameters in the field
- outdoor measurements in Freiburg / Merdingen, on Gran Canaria and in the Negev desert
- customized evaluations and useful, independent reports
- determination of degradation indicators using comparative measurements on pre-aged and new modules
- benchmarking of different module types against reference modules or our inventory of test samples
- climate and site-specific Energy Rating



*Test stand on the premises of the Instituto Tecnológico de Canarias (ITC) in Pozo Izquierdo, Gran Canaria, Spain.*

At our outdoor test sites, we test PV modules and their components for manufacturers and operators. The actual yield, reliability and aging behavior of new module types have a significant influence on the economic viability of solar power plants and the costs of the energy transition. Our independent analyses facilitate the selection of durable components for plant operators, investors, banks and insurance companies.

## Precise Benchmarking for Innovative PV Modules

The solar test sites are ideal for testing innovative technologies, such as bifacial modules, TOPCon technology, heterojunction technology (HJT), perovskite PV, organic PV (OPV) and tandem PV. Under outdoor conditions, comparative measurements can be performed with reference modules from Fraunhofer ISE as well as with competitor products. Depending on the technology and application, different questions arise. Thus, we customize test programs and accompanying analyses with our clients as required.



*Test stand on the grounds of Ben-Gurion University of the Negev, Sede Boqer, Israel.*

## Comprehensive Performance Analysis

We combine the monitoring data from the outdoor performance test site with precision measurements from the accredited CalLab PV Modules, accelerated aging tests from the accredited TestLab PV Modules as well as with highly sensitive degradation analyses using processes which we have developed. In all, Fraunhofer ISE offers a unique platform for comprehensive performance analysis:

- precision measurements in the laboratory under standard conditions and according to IEC 61853 (Energy Rating)
- reproducible preconditioning in our TestLab PV Modules (accelerated aging in climatic and UV chambers)
- direct comparison of aged and new modules in real operation with relative measurements for early identification of technology, material, and design-specific degradation risks
- combination with parameter-based simulation calculations for module performance and energy rating for product optimization
- reduction of the overall uncertainty for module performance and lifetime yield