



# PV Supply Chain Services

Mitigate sourcing risks.  
With TÜV Rheinland.

[www.tuv.com](http://www.tuv.com)

 **TÜVRheinland®**  
Precisely Right.



## From supplier selection to final installation, PV supply chain experts from TÜV Rheinland provide comprehensive support in completing successful solar projects.

Every solar project is unique, and so is our service. To meet and exceed expectations, we adjust to your individual needs. Whether you are a developer, investor, EPC contractor, lender, owner or operator, our tailored services will ensure that you are comfortable with all sourcing decisions.

For over 35 years, TÜV Rheinland has provided solutions for the solar industry – testing, certifying, inspecting and auditing. At every step along the way, we have continued to learn, improve and refine our processes.

We have decades of experience providing supply chain services for PV projects of different capacities. We have built a global network of laboratories designed to meet new challenges and grown with specialists who support and advise our clients. We are thus uniquely equipped to oversee the complex relationships and different interests in PV supply chains and enable you to master any challenge your PV project encounters.



### OUR EXPERTISE. YOUR BENEFITS.

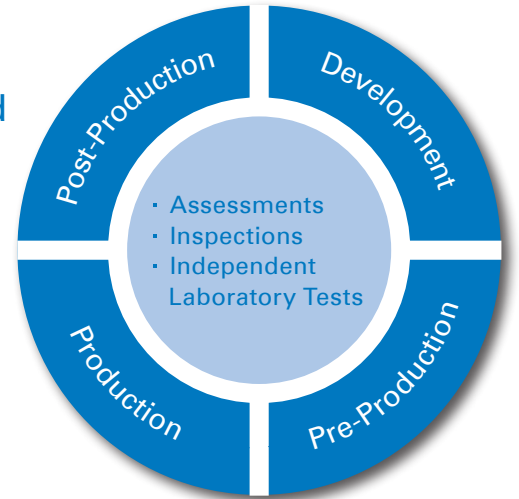
- Services are tailored to meet your project-specific requirements.
- Objective information helps you determine final suppliers.
- Increase investor, lender and insurance confidence.
- Reduced risk of faulty products at the construction site, helping you maintain project quality.
- World-class solar experts and local laboratories provide support wherever and whenever needed.





# Comprehensive service portfolio along the PV supply chain.

## For PV module, Inverter, Mounting structure and other components

Our audits and inspections of production lines identify potential weaknesses and risks, ensuring safe and qualified final products. Moreover, we test PV modules and other components in our accredited laboratories for durability, verifying that BOS components (such as mounting structures and inverters) match specifications and perform as expected. This helps improve quality, performance and compatibility by reducing the risk of serious defects and critical safety issues.

The result of this systematic quality assurance is not only the development of a technically safe and efficient PV power plant, but also bankability: investors and lenders can feel confident that your project is accounting for and addressing inevitable risks.



	Development	Pre-production	Production	Post-production
 <b>TÜV Rheinland expert team</b>	<ul style="list-style-type: none"> <li>Supplier evaluation</li> <li>Technical advisory</li> </ul>			
 <b>At factory</b>	<ul style="list-style-type: none"> <li>Factory audits</li> </ul>	<ul style="list-style-type: none"> <li>Capability assessment</li> <li>Pre-production inspection</li> </ul>	<ul style="list-style-type: none"> <li>DuPro factory inspection</li> <li>Inline quality assurance</li> </ul>	<ul style="list-style-type: none"> <li>Pre-shipment factory inspection</li> <li>Loading supervision</li> </ul>
 <b>In TÜV Rheinland's laboratory</b>	<ul style="list-style-type: none"> <li>Module benchmarking</li> </ul>	<ul style="list-style-type: none"> <li>Reliability tests</li> <li>Reference module creation</li> </ul>	<ul style="list-style-type: none"> <li>Fast verification sample tests</li> </ul>	<ul style="list-style-type: none"> <li>Final random sample tests</li> </ul>
 <b>On construction site</b>				<ul style="list-style-type: none"> <li>Post-shipment inspection</li> <li>Pre-installation testing</li> </ul>



# Independent laboratory tests

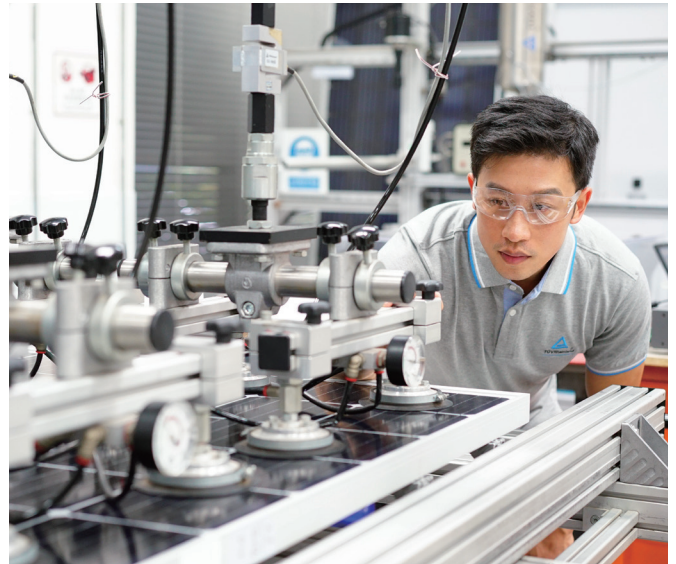
Independent tests can be performed in our accredited (ISO 17025) laboratories: Cologne (Germany), Pleasanton (USA), Bangalore (India), Milan (Italy), Shanghai (mainland China) and Taichung (Taiwan). All tests are performed under IEC standards, if applicable, and customised test sequences are offered.



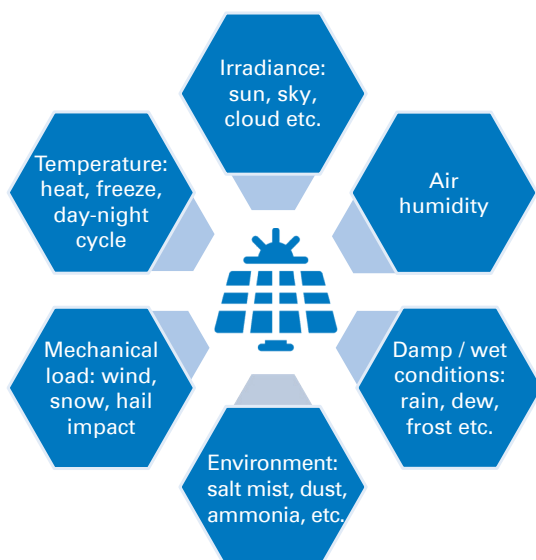
## PV module laboratory tests

### FAST VERIFICATION TESTS

- Visual inspection
- Power determination
- Electroluminescence (EL) test
- Safety tests
- Performance at different irradiance/temperature
- EVA gel content & peel-off tests
- Thermographic testing
- Potential induced degradation (PID)
- Light induced degradation (LID)
- Light and elevated Temperature Induced Degradation (LeTID)
- Bifaciality ( $\phi$ ) coefficient verification



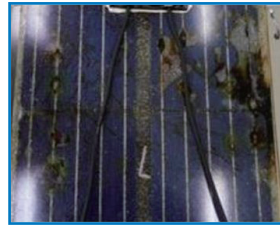
### RELIABILITY TESTS AND EXTENDED RELIABILITY TESTS



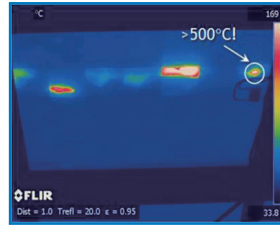
- Damp heat test (DH)
- UV precondition test
- Thermal cycling test (TC)
- Humidity freeze test (HF)
- Impulse voltage test
- Hail impact
- Bypass diode thermal test
- Hot-spot endurance test
- Outdoor exposure test
- Salt mist
- Ammonia corrosion test
- Static mechanical load
- Dynamic mechanical load

## BIFACIAL MODULE EXTENDED RELIABILITY TESTS

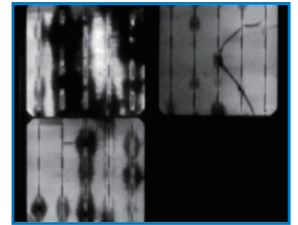
Bifacial modules have been gaining more market share recently. Solar systems using bifacial module reach higher yields compared to the monofacial systems, while facing more challenges for the long-term reliability. The higher string current may lead to an increased risk of PID, LID, junction box failure, hot spot issue, etc. Therefore, TÜV Rheinland recommend tests with higher currents to account for conditions in the field as in 2PFG 2556/06.18.



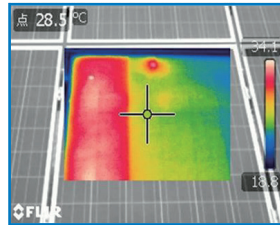
Module burnt



Hot spot



EL image of burnt module



Bypass diode defect



Melted junction box

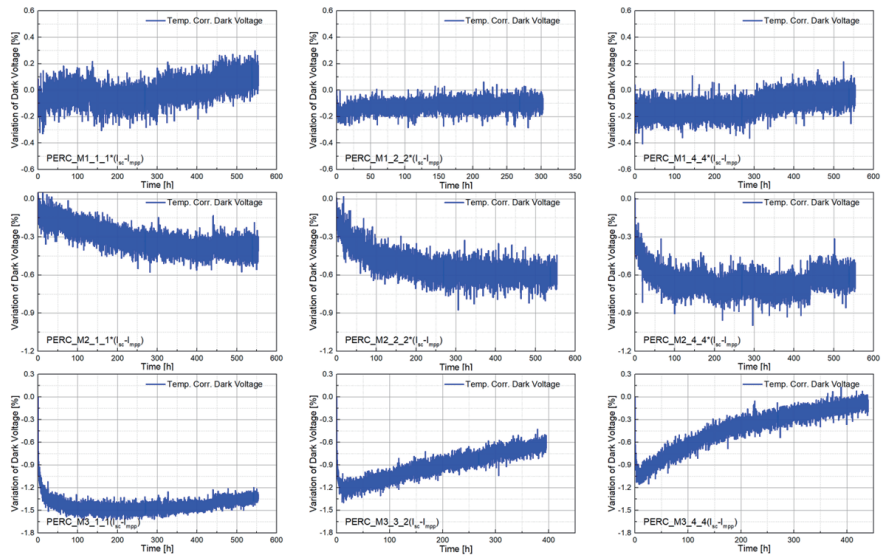


Fire

## LIGHT AND ELEVATED TEMPERATURE INDUCED DEGRADATION (LETID) TEST

PERC/PERL/PERT is the market mainstream and has gained more than 50% market share in 2019 with a further expected increase in next years. PERx module's power output may be affected negatively by light and elevated temperature induced degradation (LeTID).

TÜV Rheinland's 2 PFG 2689/04.19 test method shortens the test lead time and simplifies the test procedure while the severity of the test condition and quality of the final results is not compromised.



Current Injection:  $I_{SC} - I_{MPP}$

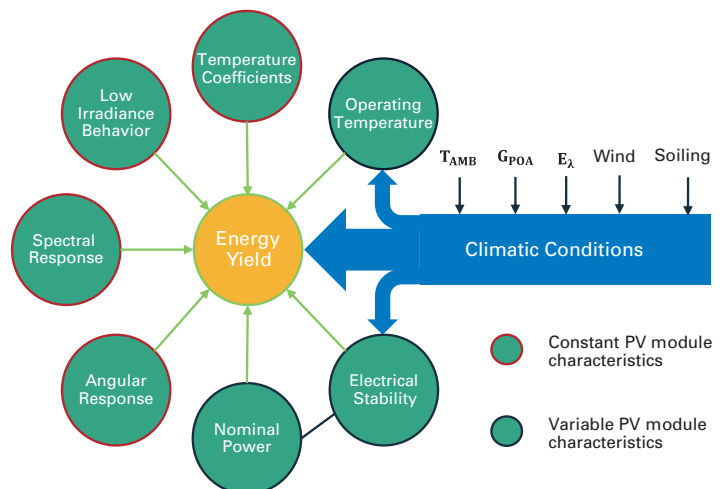
$2 * (I_{SC} - I_{MPP})$  (2 PFG condition)

$4 * (I_{SC} - I_{MPP})$

## PAN FILE DATA PACK CREATION AND VERIFICATION

The PAN File characterizes the performance of the PV module in PVsystem. With the base PAN file which only includes parameters taken from the data sheet, performance and energy yield is simulated with high uncertainty.

TÜV Rheinland maintains state-of-the-art equipment and is a leading provider for accurate power rating and testing of commercial PV modules. The critical parameters such as IAM, GTE, series resistance, spectral response, temperature coefficient etc. which are used in PAN files will be extracted from precise measurements in accordance with IEC 60891, IEC 60904 and IEC 61853 series of standards.



## PV Inverter Supply Chain Services

PV inverters are critical components of PV power systems and play a key role in ensuring the longevity and stability of such systems. Our complete service portfolio meets the requirements for safety, high performance and reliability.

### OUR COMPLETE SERVICE PORTFOLIO MEETS YOUR REQUIREMENTS FOR SAFETY, HIGH PERFORMANCE AND RELIABILITY

- Power quality testing
- Efficiency testing
- Environment testing
- Benchmark testing
- Reliability testing
- Functional safety
- Penetration testing
- Cybersecurity
- Supplier assessment
- Factory acceptance testing
- Site acceptance testing
- OND files

### SAFE AND SUCCESSFUL SOLAR PROJECTS START WITH OUR PV SUPPLY CHAIN SERVICES



## PV Mounting Structure and Tracker

PV mounting/tracker systems are becoming more and more important to the design, production, installation and maintenance of PV systems. Since solar power projects vary by regional legal requirements and site-specific conditions, each design must be considered individually. As well as adhering to local laws and regulations, project planners increasingly need to be familiar with international requirements for their projects.

TÜV Rheinland is providing tailor-made inspection and testing services to support clients in quality assessment for PV mounting systems and solar trackers.



### PRODUCT SCOPE

- Ground-mounted (fixed-tilt) racking systems
- Sloped-roof racking systems (including roof-integrated)
- Flat roof racking systems (including ballasted)
- Solar trackers (single/dual axis)
- Custom systems (e.g. floating systems)

### TAILOR-MADE TESTING SERVICES FOR MOUNTING/TRACKER SYSTEMS

- Tensile strength and compression test
- Mechanical load test
- Environment test
- Salt mist and corrosive atmosphere test
- Wind tunnel test, etc.

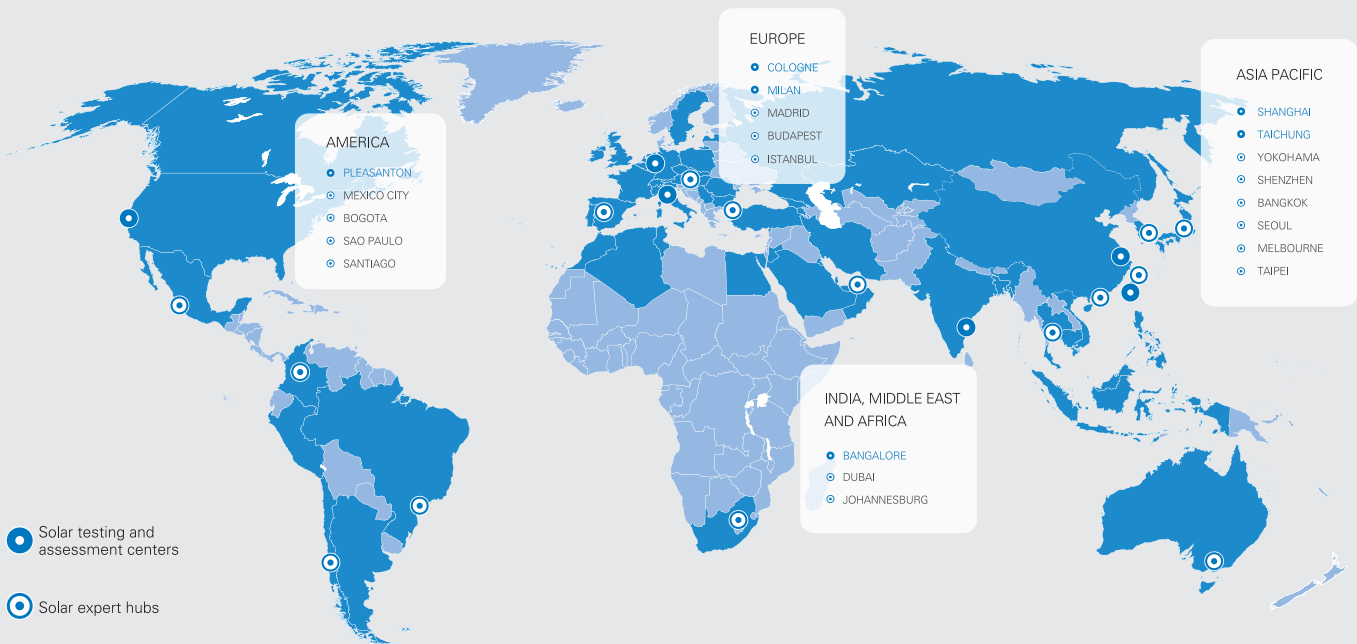
# Global network, local services.

Our testing centers with multiple accreditations in Germany, Italy, China, India and the US consist of state-of-the-art equipment and sophisticated engineering teams. Additionally, a number of outdoor measurement sites under various conditions, including dry & hot, tropical and moderate climates, ensure a wide range of assessments on the performance of PV modules. As the premier third party testing and certification institution for the PV industry, over 250 experts of TÜV Rheinland worldwide can rapidly respond to the local needs of manufacturers, retailers and investors, offering value beyond expectations. The combination of various disciplines makes us a trustworthy partner, able to advise you and play an active role in helping you achieve success.

**250+** experts

**35+** years of experience

**No.1** in PV products testing and certification



**Here for safety. Born for quality.**

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