Smart Investments in Solar & Renewable Energy

Leveraging TÜV Rheinland's Expertise for Financial Security

May Wang

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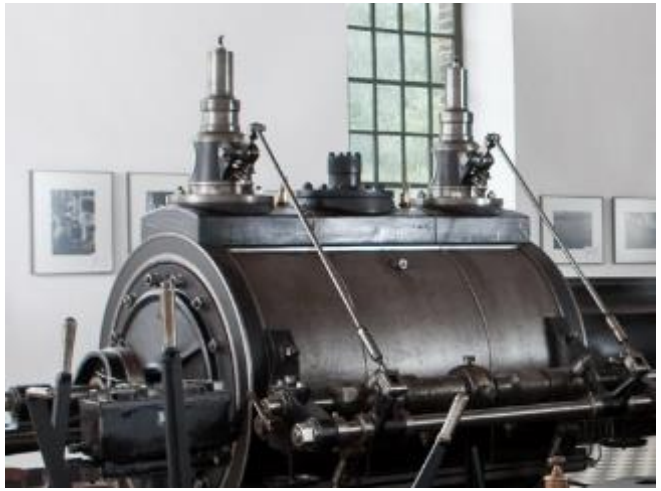
Agenda

Safety and Quality Alongside the Energy Revolution.



TÜV Rheinland was founded as part of the German Steam Boiler Association. A company with a clear mission: to make new technologies controllable.

In the fossil energy era, TÜV Rheinland has evolved, keeping pace with industrial progress and energy development.

Safety, quality and reliability are TÜV Rheinland's areas of expertise.

150 Anniversary

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Immediate Conclusion – Why TÜV Rheinland?

Your Investment with TÜV Rheinland’s 42 Years of Expertise

With over 42 years of experience, TÜV Rheinland helps investors and EPCs make informed, financially secure investments by minimizing risk, maximizing performance, and ensuring long-term project viability.

IEC TC 82

20+ working groups of IEC TC 82 for standard development have been and are being led by TÜV Rheinland.

R&D edge

The R&D competency of TÜV Rheinland is unrivaled in measuring and testing of new or innovative PV technologies and applications.

Added value

Our unique programs enable you to stand out from the competition and achieve greater success.

Global availability

Testing centers and expert hubs across the globe enable TÜV Rheinland to respond rapidly to your local needs.

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What makes TÜV Rheinland Special?

Offering tailor-made solutions for manufacturers, EPCs and investors along the value chain globally.

More than **42** years of experience in PV

Power plant inspections since **1990**

Advised on PV projects adding up to more than **20** GW worldwide

10,000 m^2 of lab testing areas

250+ PV experts worldwide

Focus on Investors' Priorities-extended bankability service

The Smart Way to Invest in Solar Energy

- Investors are not just seeking upfront savings but long-term predictable returns.
- TÜV Rheinland's extended **bankability services** provide the technical and financial confidence you need to secure funding and ensure lasting value.

TÜV Rheinland has established criteria for PV modules.

The standard includes eight test sequences the data from these tests not only allow system designers to **make reliable energy yield predictions** but also **enhance the project's credibility and appeal.**

Ranking: Superior or Good

Listed on the TÜV Rheinland website

Lead time: 6 months

Further reading: [Extended Bankability for PV module(s) | TÜV Rheinland]

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Technical Due Diligence – Your Risk Mitigation Tool

Comprehensive Technical Due Diligence (Solid investments with our solar technical due diligence)

❖ Key Benefit: Reduce risks by ensuring projects are technically sound, maximizing success rates for investors and EPCs.

Our approach to technical due diligence for PV power plants encompasses the following key branches:

- **Evaluation of the technical feasibility**
  - Contractual management
  - Risk management
- **Inspection and fault detection** **of PV system design, PV components, construction and performance**
  - Plant construction monitoring
- **Assessment of plant's performance on energy yield predictions**
  - Power determination of **PV modules**
- **Complete portfolio** **thoroughly detailing the results of our inspection and assessment services**.

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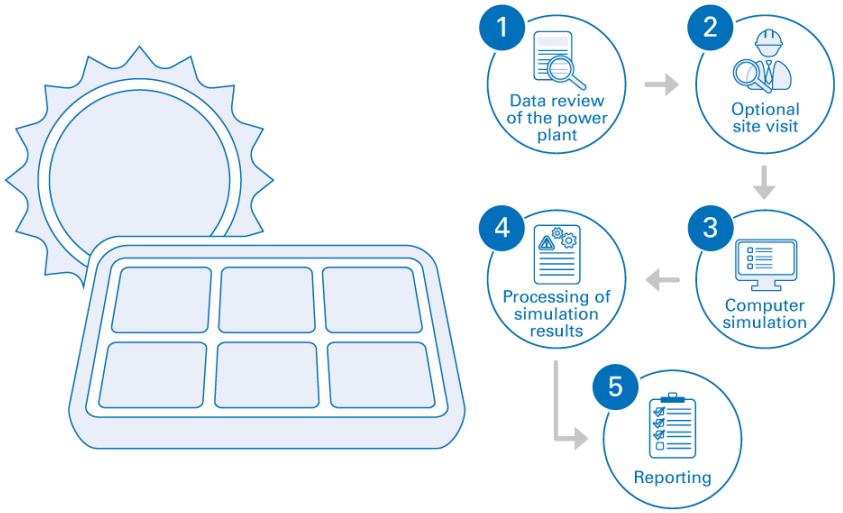
Performance Forecasting – Know Your Returns

Accurate Yield and Performance Forecasting

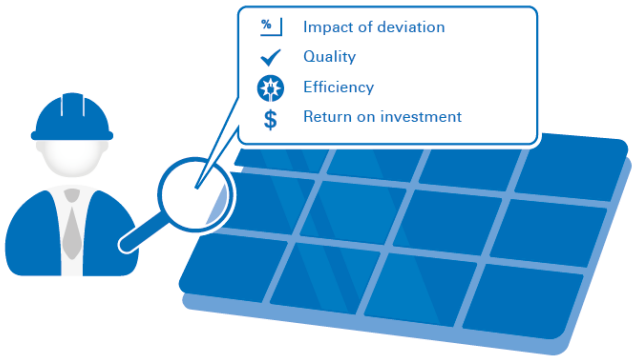
❖ Key Benefit: Investors get reliable, data-backed predictions of financial returns and operational performance.

ENERGY YIELD ASSESSMENT



We use meteorological data and performance modeling to predict energy yields with precision.

PERFORMANCE RATIO ASSESSMENT – KEY OUTCOMES



We take into account all the particulars related to your specific project: solar resources, technical system design, energy loss and any uncertainties related to each step of the simulation.

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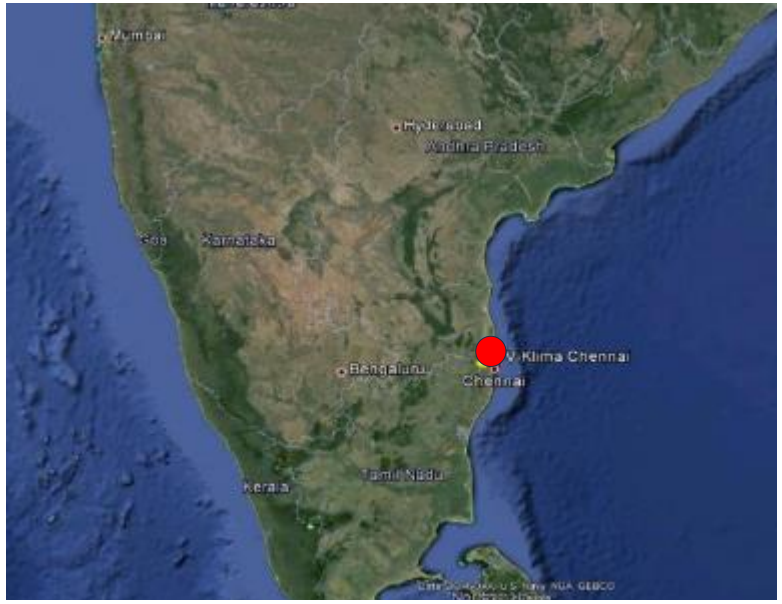
Global Energy Yield Rating of PV Modules.

Analysis of PV module performance behaviour under real operating conditions.

Tempe, USA	Cologne, Germany	Thuwal, Saudi Arabia	Chennai, India	Inner Mongolia, China
Bwh (Dry, sub-tropical desert)	Cfb (Mild mid latitude, marine west coast)	Bwh (Dry, sub-tropical desert), sandstorm impact	Aw (Tropical humid, tropical savanna)	Dsa (Dry, continental), significant temperature difference

Global Energy Yield Rating of PV Modules.

Test location: Chennai, India



- Geographical position: 13°N / 80°E
  35 m above sea level
- Climate conditions: Aw (Tropical humid, tropical savanna)

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Global Energy Yield Rating of PV Modules.

Test location: Tempe, Arizona, USA

- Geographical position: 33.4°N / 111.9°W
  358 m above sea level
- Climate conditions: Bwh (Dry, sub-tropical desert)

Global Energy Yield Rating of PV Modules.

Test location: Cologne, Germany

- Geographical position: 50.6°N / 7.0°E
  53 m above sea level
- Climate conditions: Cfb (Mild mid latitude, marine west coast)

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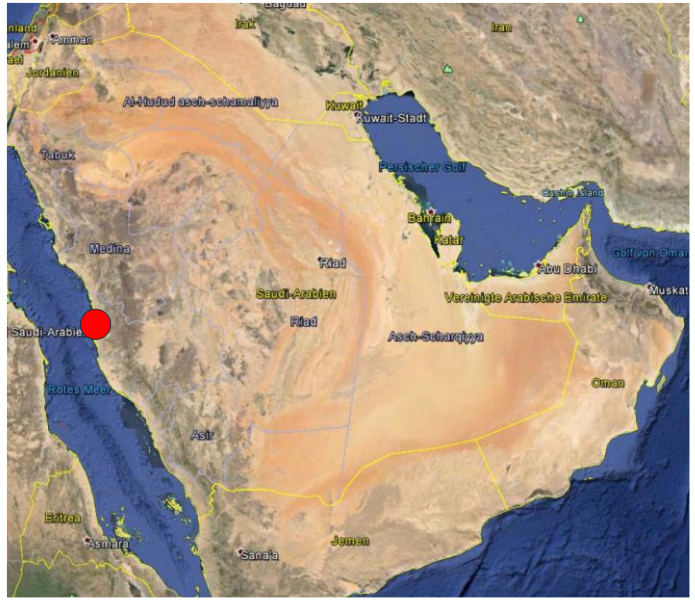
Global Energy Yield Rating of PV Modules.

Test location: Thuwal, Saudi Arabia



- Geographical position: 22.304°N / 39.108°E
  3 m above sea level
- Climate conditions: Bwh (Dry, sub-tropical desert), sandstorm impact

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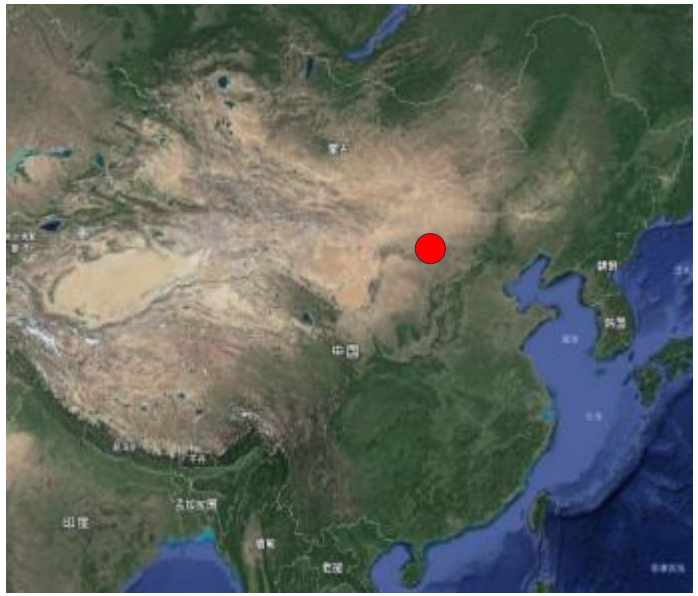
Global Energy Yield Rating of PV Modules.

Test location: Inner Mongolia, China



- Geographical position: 40°N / 111°E
  1094 m above sea level
- Climate conditions: Dsa (Dry, continental), significant temperature difference

Certification & Compliance – Building Trust

Global Certification and Compliance Expertise

We meet **international standards** (IEC, UL) and **local regulations** to ensure projects are finance-ready.

Compliance boosts investor confidence by ensuring safety, quality, and regulatory approval.

Take advantage of our **global test laboratory network**, in which we use the latest measurement methods and procedures to ensure compliance of PV products.

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TÜV Rheinland Global PV Testing Network.

GERMANY

Cologne

1,500 m²	Laboratory area
Categories	PV modules, components, inverters, ESS
1982	Year established
Accreditations	ISO 17025, SRCC, VKF, CBTL, CEC, MCS, NRTL

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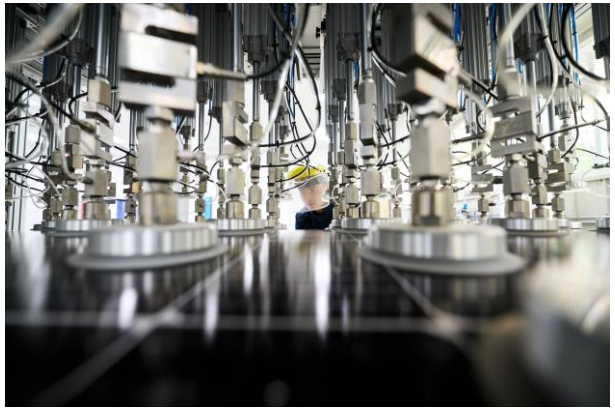
TÜV Rheinland Global PV Testing Network.

MAINLAND CHINA

Shanghai/Taicang

5,000 m^2	Testing area
Categories	PV modules, components, inverters, ESS, PV trackers
2007	Year established(Year 2022 moved to Taicang)
Accreditation	ISO 17025, CBTL, CEC, NRTL, MCS, UAE Civil Defense



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TÜV Rheinland Global PV Testing Network.

INDIA

Bangalore

1,114 m^2	Laboratory area
Categories	PV modules, inverters, solar pumping systems
2010	Year established
Accreditations	ISO 17025, CBTL, MCS, NRTL, CEC

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Lifecycle Management – Sustaining Your Asset Value

Ensuring Long-Term Asset Performance

Development | **Engineering** | **Procurement** | **Construction** | **Commissioning** | **Acceptance** | **Operation**

Feasibility study

- Design review
- Site evaluation
- Energy yield assessment
- Glare assessment

Technical requirements

- Design optimization
- Components check
- Production estimate
- EPC & O&M contract review

Product and vendor quality assurance

- Factory audits
- Purchase agreements review
- Production inspection
- Module and component tests

Inspection and construction monitoring

- Quality control and conformity inspection of civil, mechanical, electrical engineering, technical execution and performance
- Progress and critical milestone monitoring

Safety, quality and power control

- Safety-related inspection
- Functional check
- Test protocol verification
- Thermographic scans
- On-site tests and measurements

Final acceptance and asset certification

- Performance ratio (PR) assessment
- Provisional and final acceptance certification
- Technical documentation review

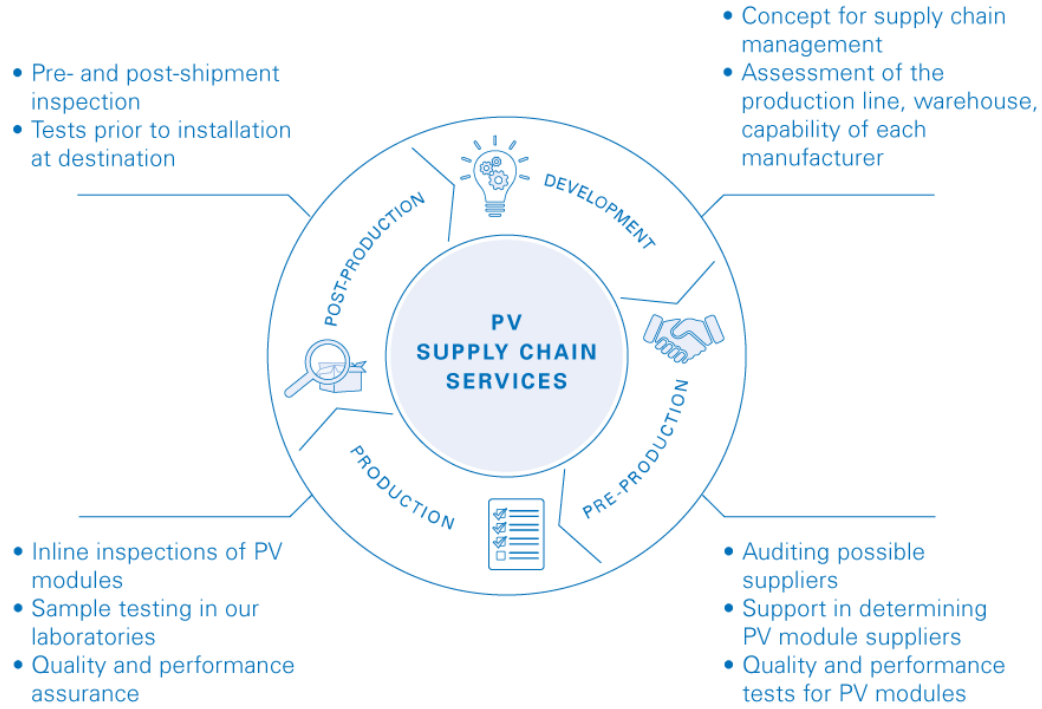
Regular monitoring

- O&M report review
- Refinancing due diligence
- Periodic power and warranty inspections
- Failure analysis
- Technical due diligence
- Power optimization

Supply Chain Validation – Secure Your Components

Validating Critical Components and Supply Chain

	Development	Pre-production	Production	Post-production
TÜV Rheinland expert team	▪ Supplier quality evaluation and ranking ▪ Supplier supply chain traceability verification and ranking ▪ ESG capability assessment ▪ Technical advisory			
At factory	▪ Factory audits	▪ Capability assessment ▪ Pre-production inspection	▪ DuPro factory inspection ▪ Inline quality assurance	▪ Pre-shipment factory inspection ▪ Packing/loading inspection
In TÜV Rheinland's laboratory	▪ Module benchmarking	▪ Reliability tests ▪ Reference module creation	▪ Fast verification sample tests	▪ Final random sample tests
On construction site				▪ Pre-installation testing ▪ Post-shipment tests with mobile solar lab (only in Europe) ▪ Post-shipment inspection (quality control and conformity) ▪ On-site inspections (claim assessment, Failure analysis)



Further reading: [tuev-rheinland-2024-05-supply-chain-brochure-en.pdf]

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PV Supply Chain Services

Our services can be used individually or combined in a package from pre-order to post-shipment.

- **Development**
  - Assessment of the production facilities and manufacturers
  - Performance optimization with best practice experiences
- **Pre-production**
  - Potential supplier auditing and selection
  - PV module and component quality and performance testing
- **Production**
  - Inspection services along the production period
  - Spot-check testing during production
  - Quality assurance and control
- **Post-production**
  - Pre-installation testing
  - Site acceptance testing
  - Failure analytics in the field

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ESG and Sustainability – Aligning Investments with the Future

Sustainability and ESG Compliance

Sustainability reporting and ESG related disclosures are the key focus for businesses as regulators, investors, consumers and other stakeholders demand greater transparency and continuous improvement of sustainability performance.

> TÜV Rheinland demonstrated a deep understanding of nuances related to our industry, provided a structured approach, and guided us with professionalism and care. Their suggestions were insightful and helped us to further strengthen our sustainability work.
>
> VARNER

Further reading: [Sustainability and ESG Assurance | WO | TÜV Rheinland (tuv.com)]

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One-stop Solar Business Solutions.

EPCs & Manufacturers

We support you with comprehensive solutions that can take you to a whole new level.

Plant Owners

We offer all-round technical support over the entire value chain and throughout a PV plant's lifetime.

Finance Institutions

We provide an independent perspective to help strengthen and reinforce solid investment decisions.

PV Product Lifecycle

Quality Assured

PV Asset Lifecycle

Bankability

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Let's Discuss Your Next Solar Investment!

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