Independent Engineering (IE) Services for Photovoltaic Power Plants Failures and Risk Management

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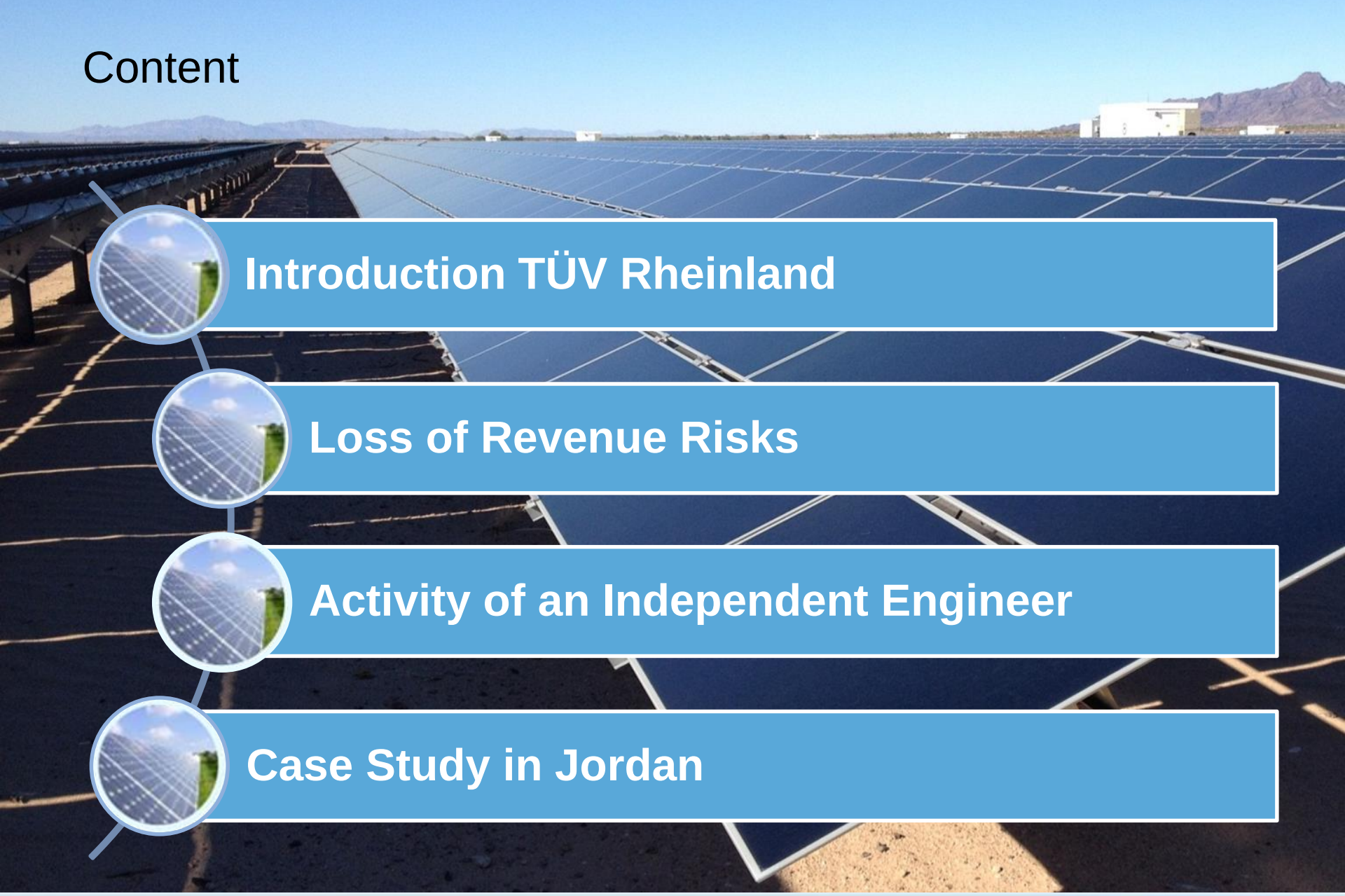
Content



- Introduction TÜV Rheinland
- Loss of Revenue Risks
- Activity of an Independent Engineer
- Case Study in Jordan

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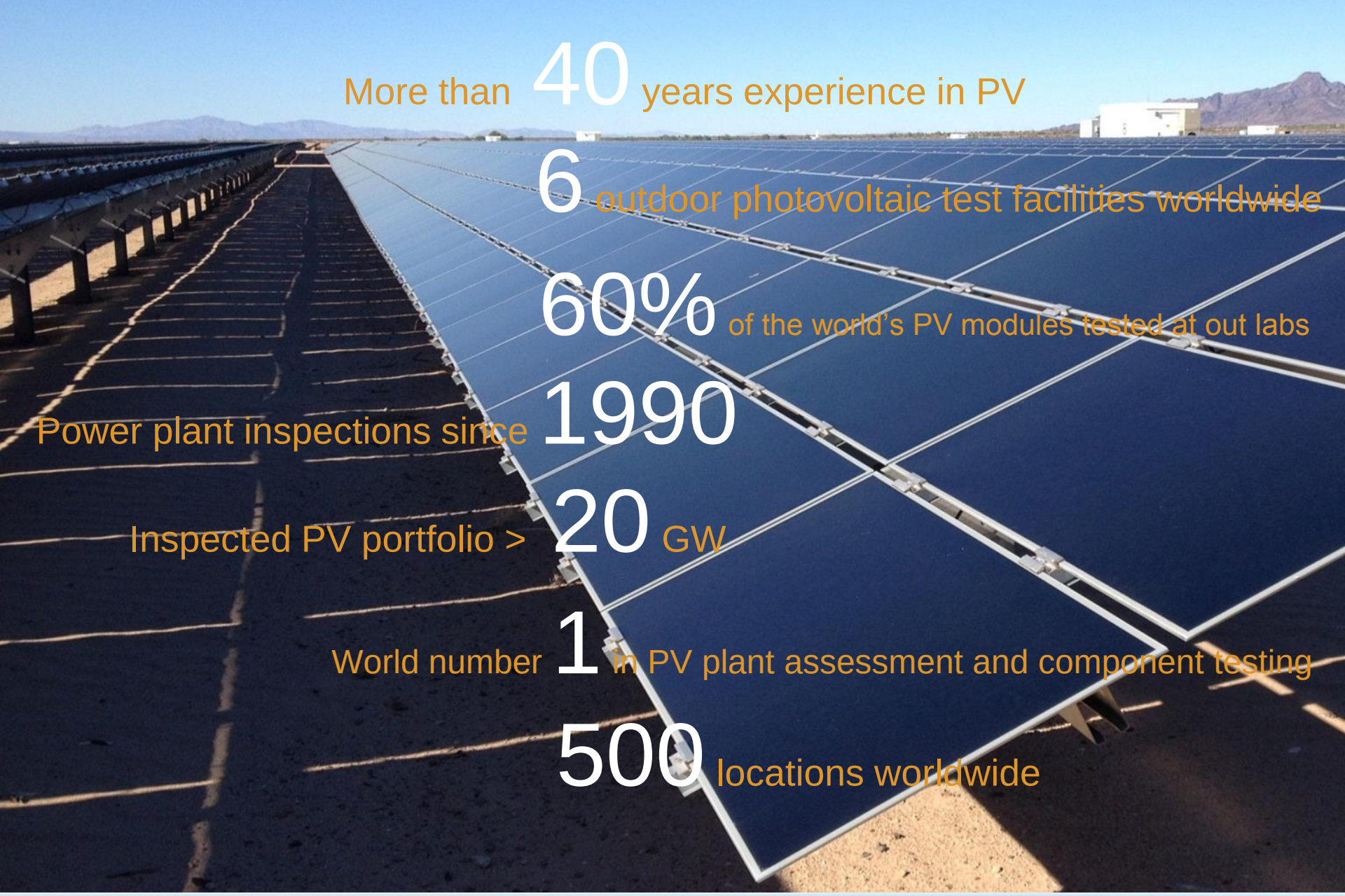

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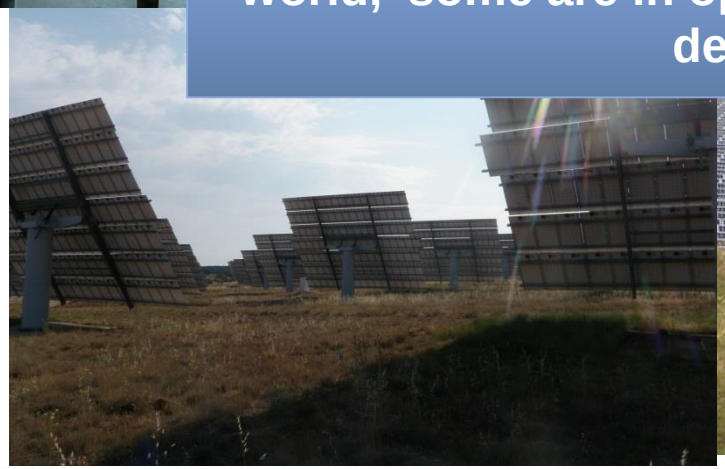
Quality: Market Situation

Large scale PV plants are being built all over the world, some are in operation for more than a decade.



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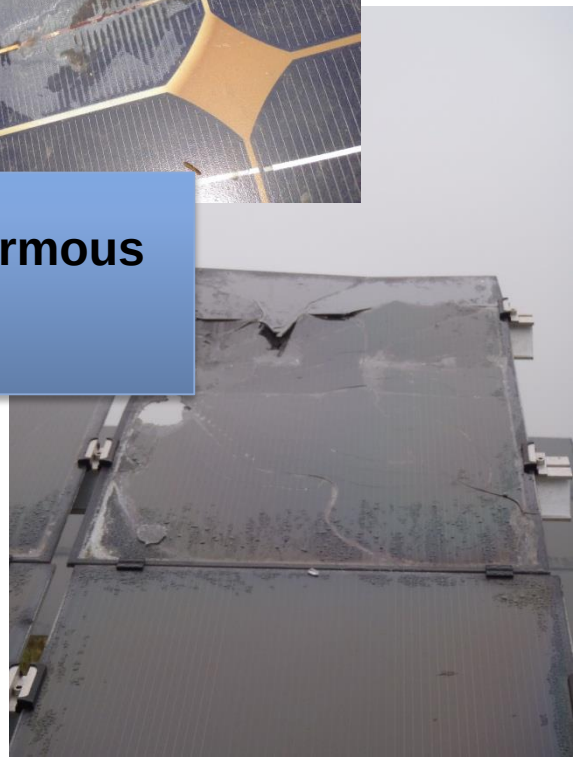
Quality: Market Situation

Unfortunately some PV plants have enormous quality problems.



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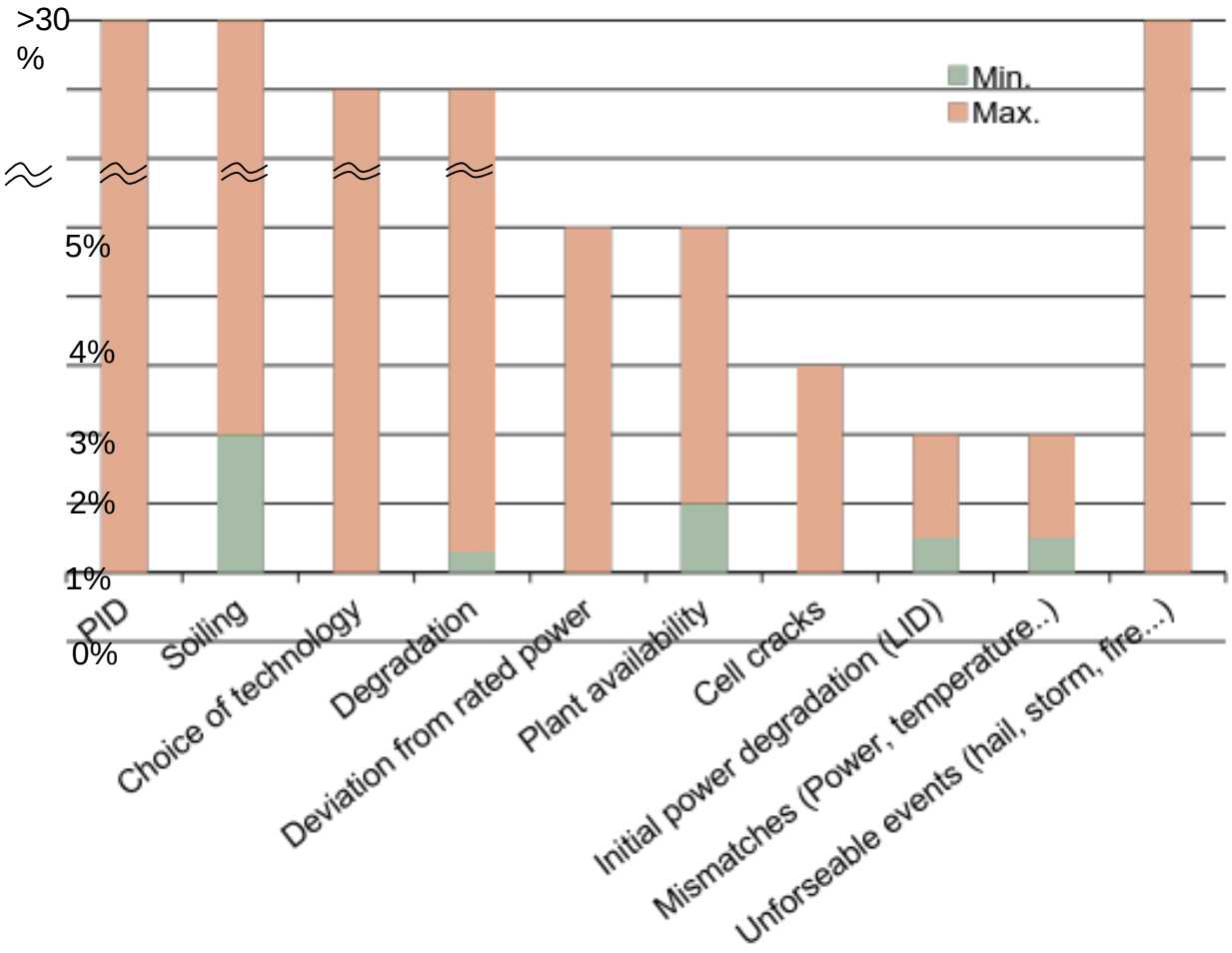
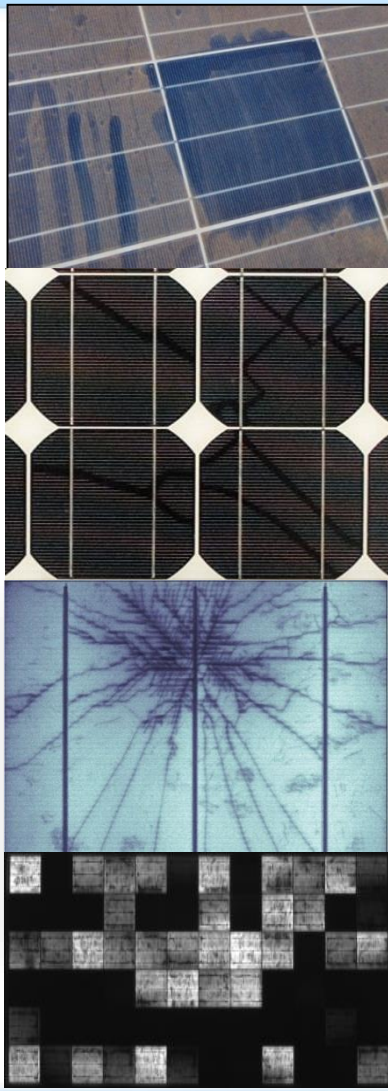
Examples of Yearly Performance Losses, Potential Risks





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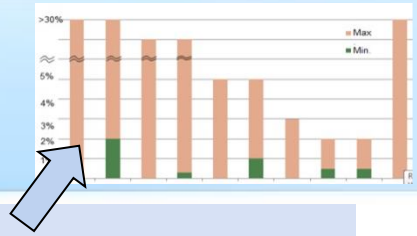
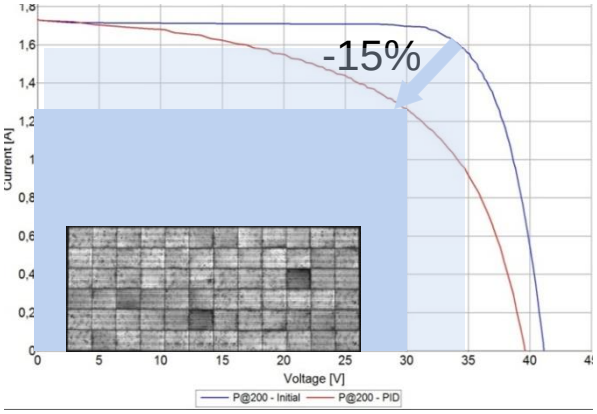
Precisely Right.

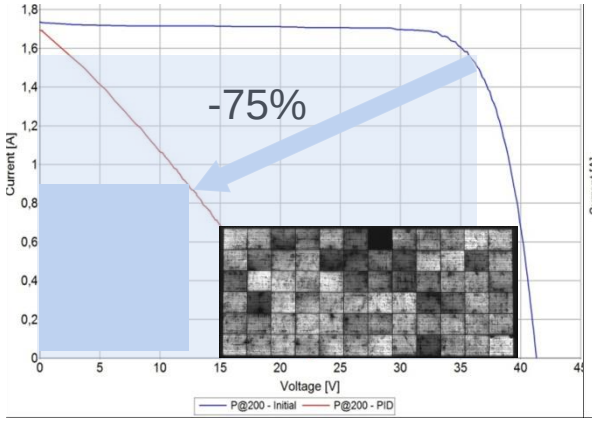
Potential Induced Degradation
Performance Killer no. 1

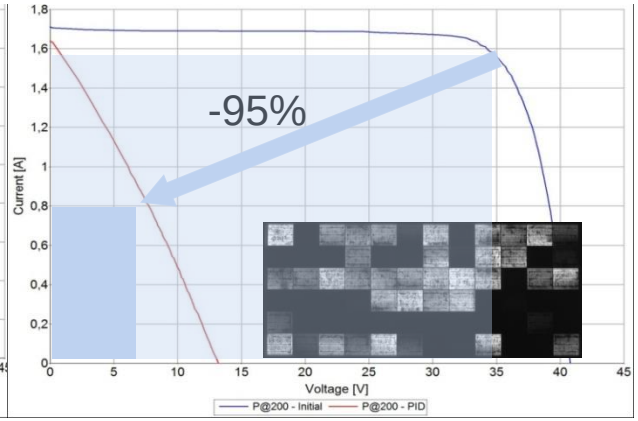


- Performance killer number one: potential induced degradation (PID)
  (occurs in cases of high voltage, sensitive module/material combinations and damp environments – e.g. caused by condensation, high humidity)
- Reversible process through grounding or counter-potential (investments required)

Test results of a PID test of PV modules from large-scale PV systems







! Knowledge of PID sensitivity of PV modules is necessary.
All material combinations of a module must be considered to declare it PID-free!

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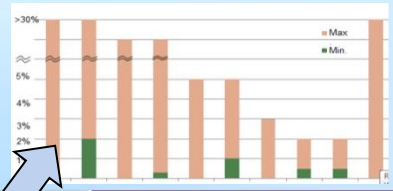
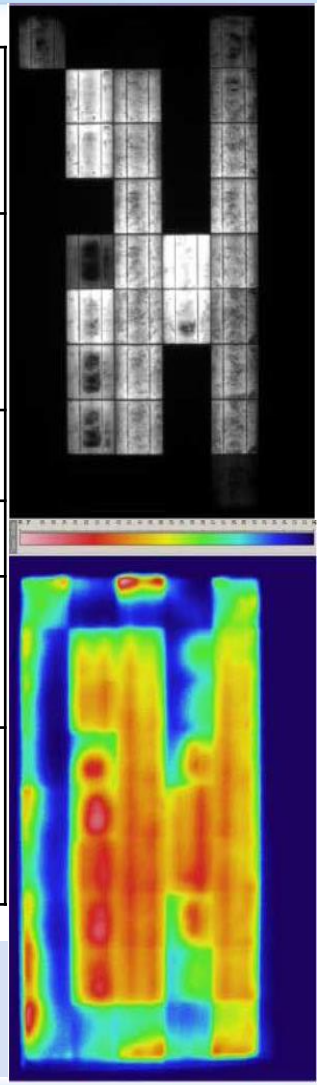
Potential Induced Degradation
Mitigation Cost Example



Description	Potential induced degradation is a performance loss in PV modules, caused by so called stray currents
Performance losses	8 % (failure rate 40 %, 20 % power loss of affected modules) 160 kWh/kWp/a (spec. yield 2,000 kWh/kWp) **700,000 $US/a** for 40 MWp plant (0.1 €/kWh)
Mitigation	Testing of the PV modules
Repair method	Installation of PV grounding kits
Cost to fix and repair	**100,000 $US** 2,200 $US per inverter x 40; incl. installation cost
Cost of mitigation measure	Testing of modules; **10,000 $US** for sample testing for PID resistivity 0.25 $US/kWp



! **1.5 Mio $US** loss after 2 years incl. repair costs versus
10 k $US mitigation costs

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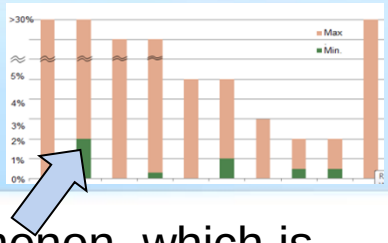
Soiling



- Dust deposition on the PV module surface is a complex phenomenon, which is mainly influenced by the environmental/weather conditions, mounting principle and glazing characteristics.
- Performance losses are site-specific and can strongly depend on O&M work.

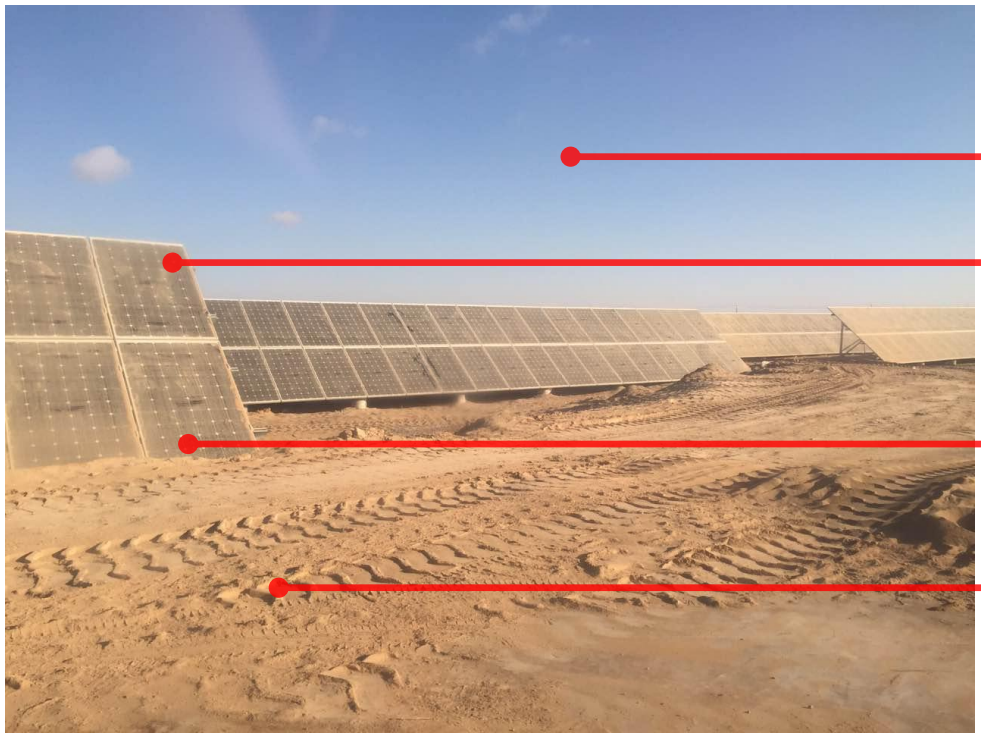


Photo: TÜV Rheinland Shanghai

Climatic impacts

Non-uniform soiling, glazing characteristics

Installation conditions

Surrounding environment

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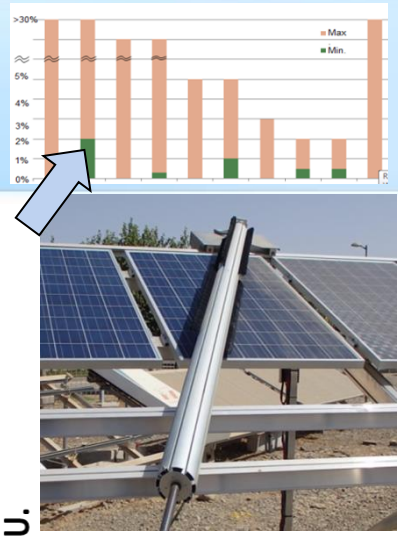
Soiling
Example Arizona



Annual soiling loss
2014: -3.6 %
2015: -1.2 %
Average daily SLF
- 0.22 % to - 0.67 %

! Local conditions need to be taken into account for O&M contract. Cleaning measures increase O&M cost significantly.

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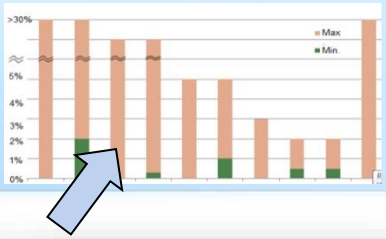
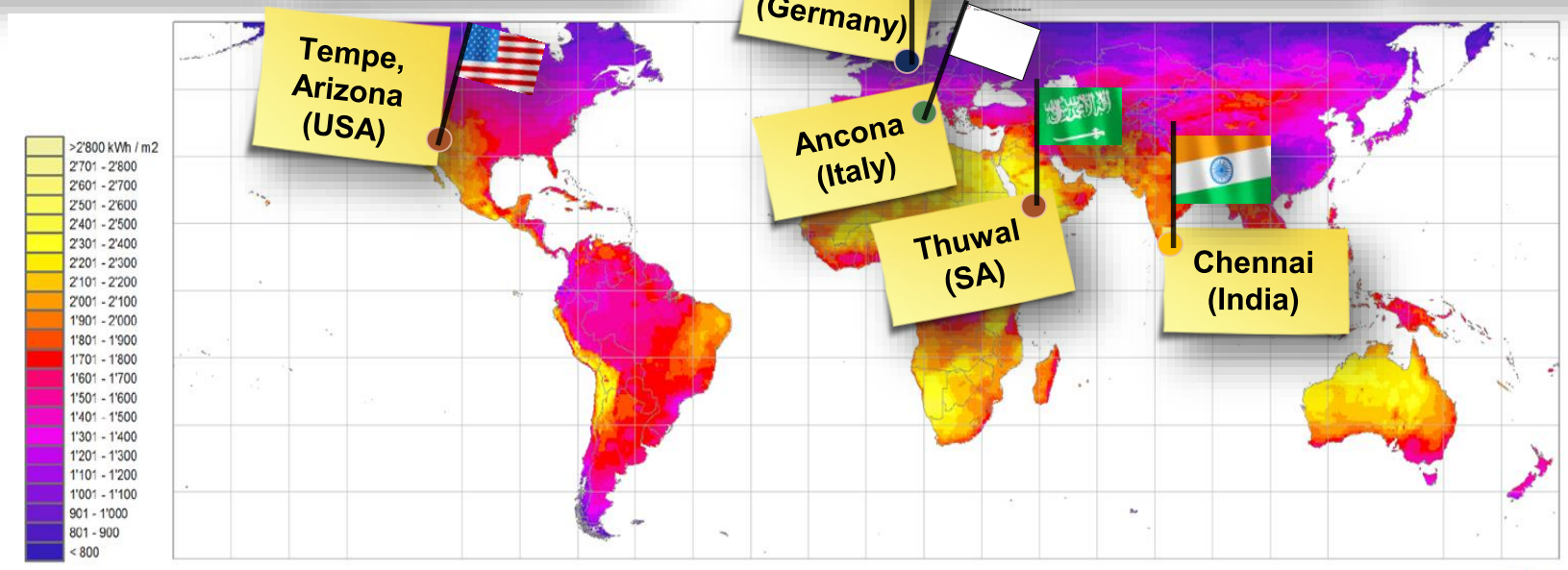
Choice of Technology
Global Energy Yield Benchmark









- Mild mid latitude Marine West Coast
- Mild mid latitude Mediterranean
- Tropical Humid, Savanna
- (subtropical) Desert, potential sandstorm impact

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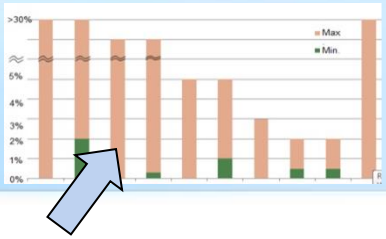
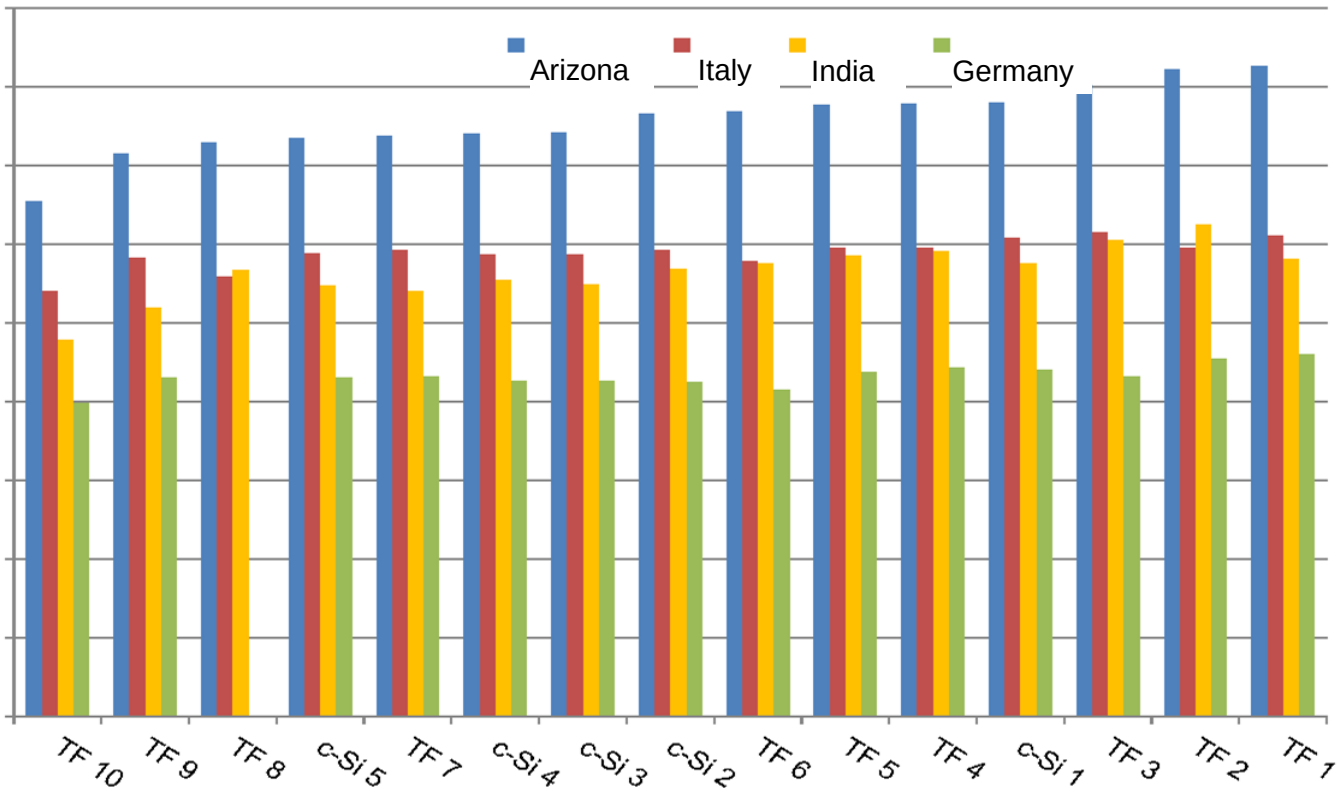
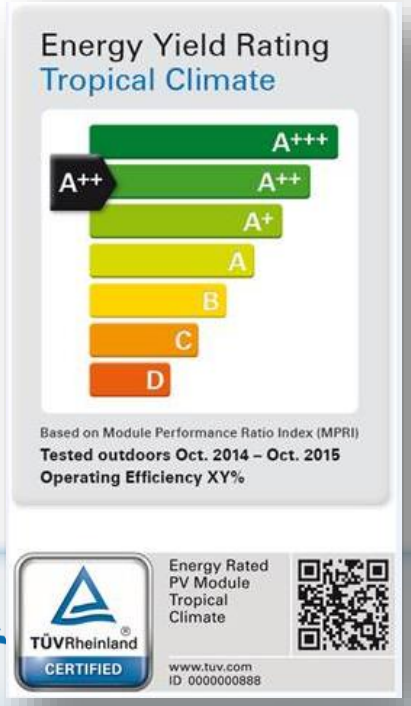
Choice of Technology
Global Energy Yield Benchmark





	Variation between technologies
Italy	**12 %**
Germany	**14 %**
India	**23 %**
Arizona	**21 %**



! Choice of technology and optimised product is crucial for high energy yield and return of investment.

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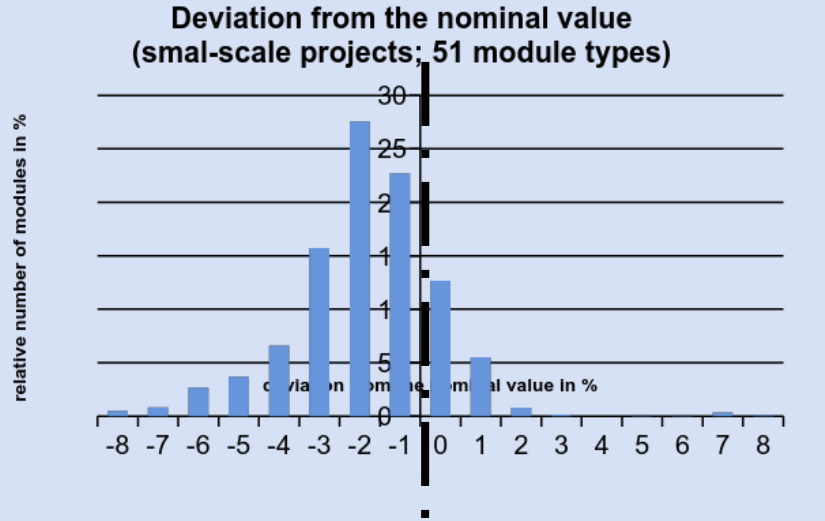
Deviation from Rated Power

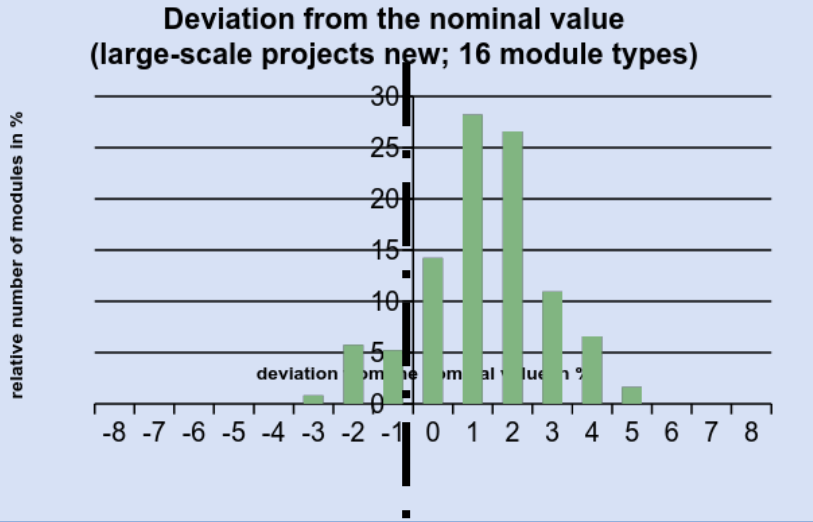
Results of performance measurements in the laboratory (2010–2013)

Following doubt about performance (modules that are new or as good as new, operation < one year)



Investors: (Court-) admissible controls necessary

Contractually agreed measurements prior to installation in large-scale systems



Investors: Measurements secure module performance

!

Critical performance evaluation (measurement) necessary
High level of measurement precision required for use in court

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Overview: Activities of IE

Review of Testing Procedures

Monitor and Witness of Testing

Components Inverters PV facility	Energy yield Export capacity Noise level	Construction (Cabling, tracking system, safety equipment, …)	Commissioning (witnessing of array, inverter commis-sioning, LV/MV tests ….	PV Performance Grid code compliance, validation of test protocols, start date ref. ...	Module Perform. (Lab testing of modules, energy yield validation, …)	Noise Level (noise level testing, determination of environmental impacts)

Supervision and Testing

- **Review of design, documentation and system specification from EPC**
- **Witnessing safety, performance and quality tests**
- **Evaluation of cleaning and O+M concepts and contracts**
- **Quality assessment of product and system components through testing and inspection**

Reporting and Adaption

Safety, Quality & Performance

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Case Study - Jordan

Project:

- 10 MW PV installation near Aqaba

Client:

- Shamsuna Power Company

Tasks:

- PV module measurement
- Review of commissioning procedures
- Witnessing of testing
- Construction supervision
- Mechanical completion certificate
- Calculation of export capacity
- Acceptance test supervision and evaluation
- Commercial operation date certificate
- Noise emission measurement

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Planning Phase
Environmental Impacts – flash flood and other sudden events

Case of Sudden Unexpected Environmental Impacts

Project Company:

- Determination of potential unexpected environmental impacts such as strong (sand) storms, floods, lightning…
- Definition of counter measures to reduce potential risks from such as events

IE obligations:

- Evaluation of documented concepts against influences to performance losses and safety issues (isolation requirements)
- Identification of missing concepts and impacts

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Commissioning Phase
Quality Measurements in the Lab

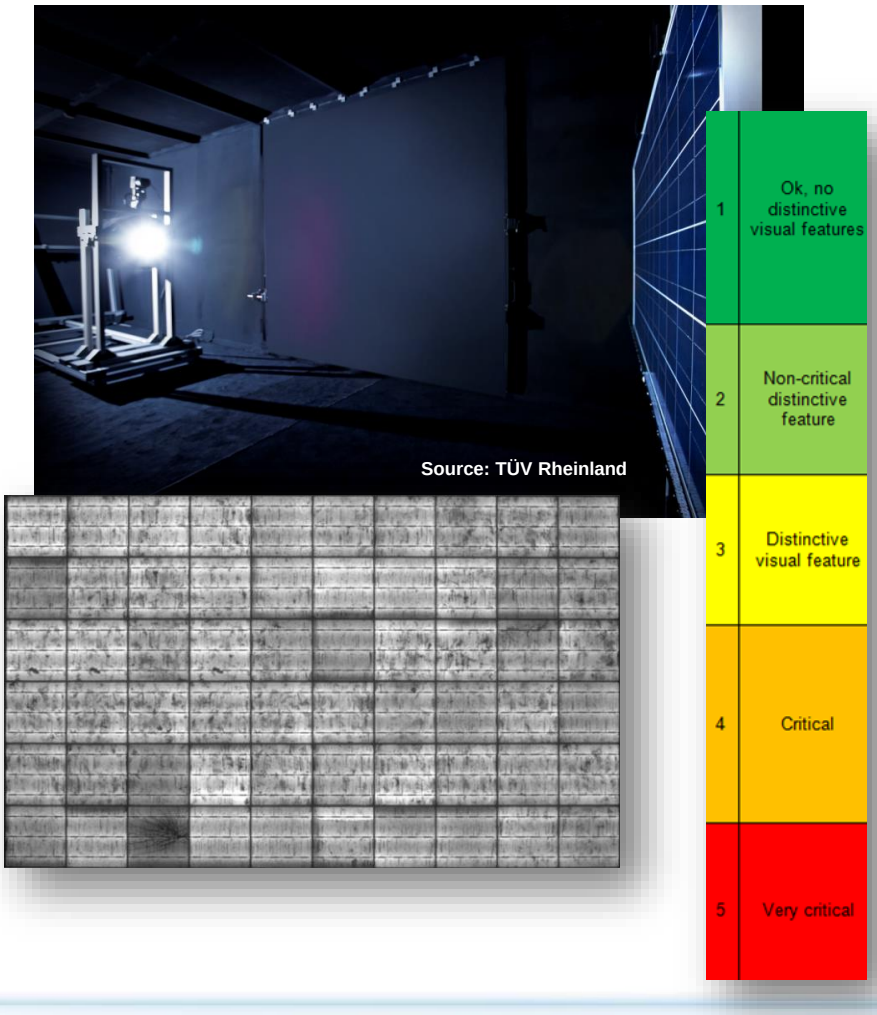
Sample Testing of PV modules

Project Company:

- Determination of actual export capacity of the plant

IE obligations:

- Random selection of representative test samples for verification testing
- Lab testing with AAA flash light simulator acc. to IEC 60904
- EL imaging and quality rating
- Verification of export capacity: yield validation with module data



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Commissioning Phase
PV arrays and inverter

Commissioning Testing

Project Company:

- PV array commissioning testing
- Inverter commissioning testing
- MV/LV tests
- I&C equipment tests

IE obligations:

- Confirmation of provided materials and supply as stated in the planning documents
- Validity check of certifications
- Commissioning
- Evaluation of monitoring system
- Additional: noise level testing (to environment)

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Test Phase
Performance after Commissioning

Performance Test Phase: e.g.10 days

Project Company:

- Measurement of continuous energy production
- Performance ratio (PR) comparison with monthly estimation

IE obligations:

- Check of system grid code compliance (against standards and local codes)
- Check of commercial operational date
- Validation of PR
- 5-year (annual) check-up of PR
- Certification for the successful PV performance test

Operation Phase – Soiling
Cleaning Concepts

Cleaning and O+M Concepts

Project Company:

- Determination of long-term cleaning and O+M concept
- Monitoring hardware and concept
- Documentation
- Technical realization
- Cost modelling

IE obligations:

- Validation of concepts against harmonized standards, such as IEC 62446
- Evaluation of monitoring devices, strategy and maintenance cycles
- Effectivity of cleaning concepts and evaluation of technical realization (automated, manual, labor…)

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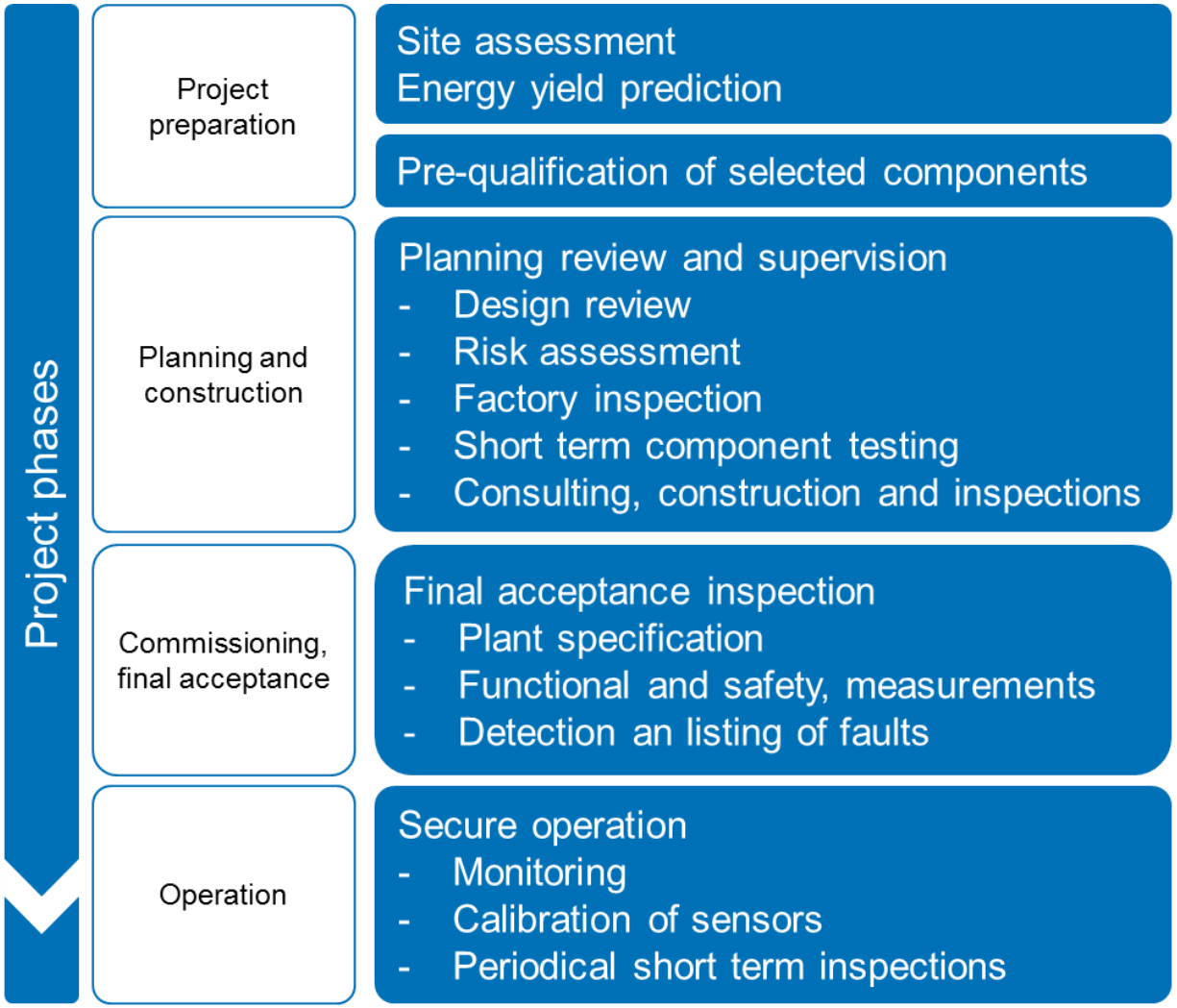
Risk Minimization / Profit Optimization
Through engagement of third party

Comprehensive quality assurance for PV plants in project phases.

TÜV Rheinland is the competent partner to offer:

- Technical Advisory
- Owners and Lenders engineering
- Component (pre-)qualification
- Buyer's services
- Energy yield prediction and verification
- PR assessment
- Performance optimization
- Final acceptance inspections
- Warranty inspections
- Transaction inspection
- Sensor calibration



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Thank you very much for your attention!

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Selected reference cases: www.tuv-e3.com/solar

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