Quality as global standard for solar PV projects, processes and products

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140 anniversary
1872 - 2012

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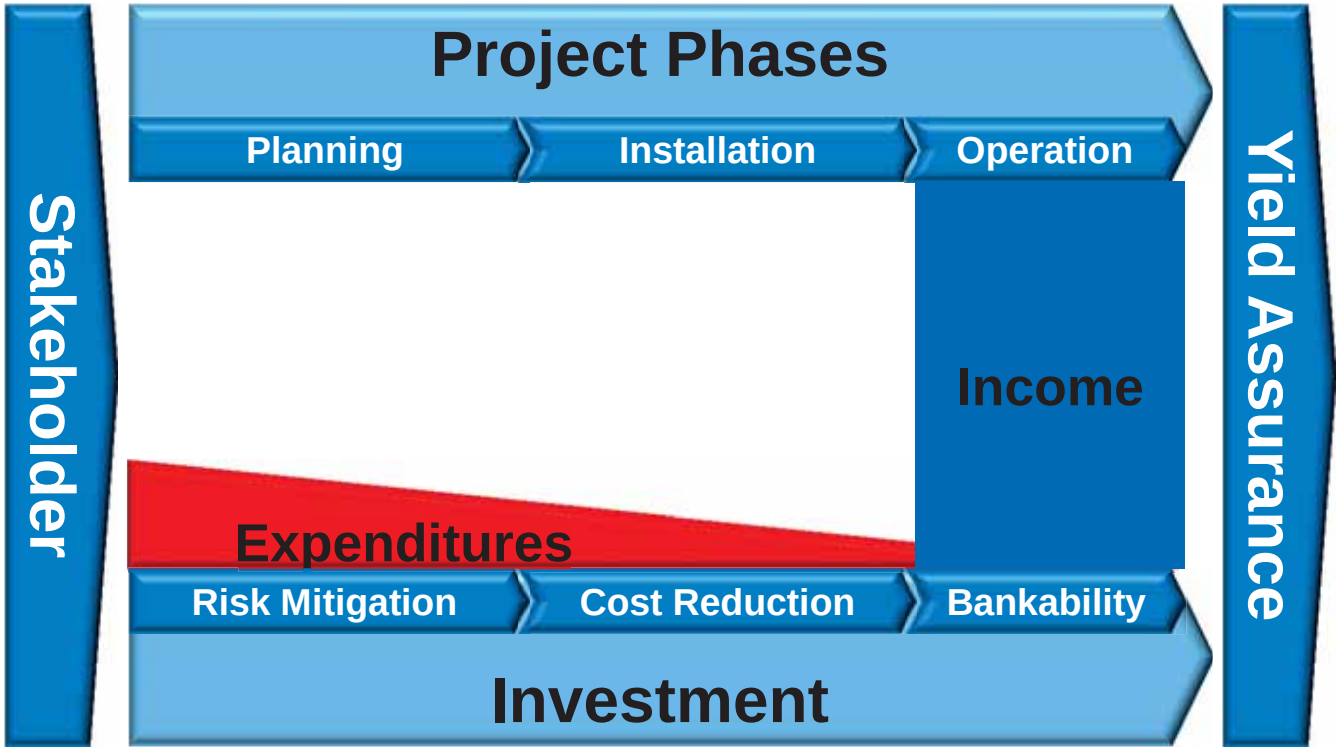
Table of content

Introduction TÜV Rheinland
Global market leader in testing & certification of photovoltaic modules

- TÜV Rheinland operates 6 accredited PV laboratories (Cologne, Bangalore, Daya/Taiwan, Yokohama, Shanghai and Tempe/Arizona)
- More than 25 years experience in the field of photovoltaic at the head quarter in Cologne, Germany
- Approx. 60% market share in testing & certification of solar panels (global market leader)
- Team of 70 engineers and technicians in Cologne (partly > 25 years PV experience), worldwide 250 PV experts
- Active participation in the important standardization committees
- Research and development in the area of module qualification (characterization and life-time assessment)

Overview
Quality Assurance for PV Power Plants



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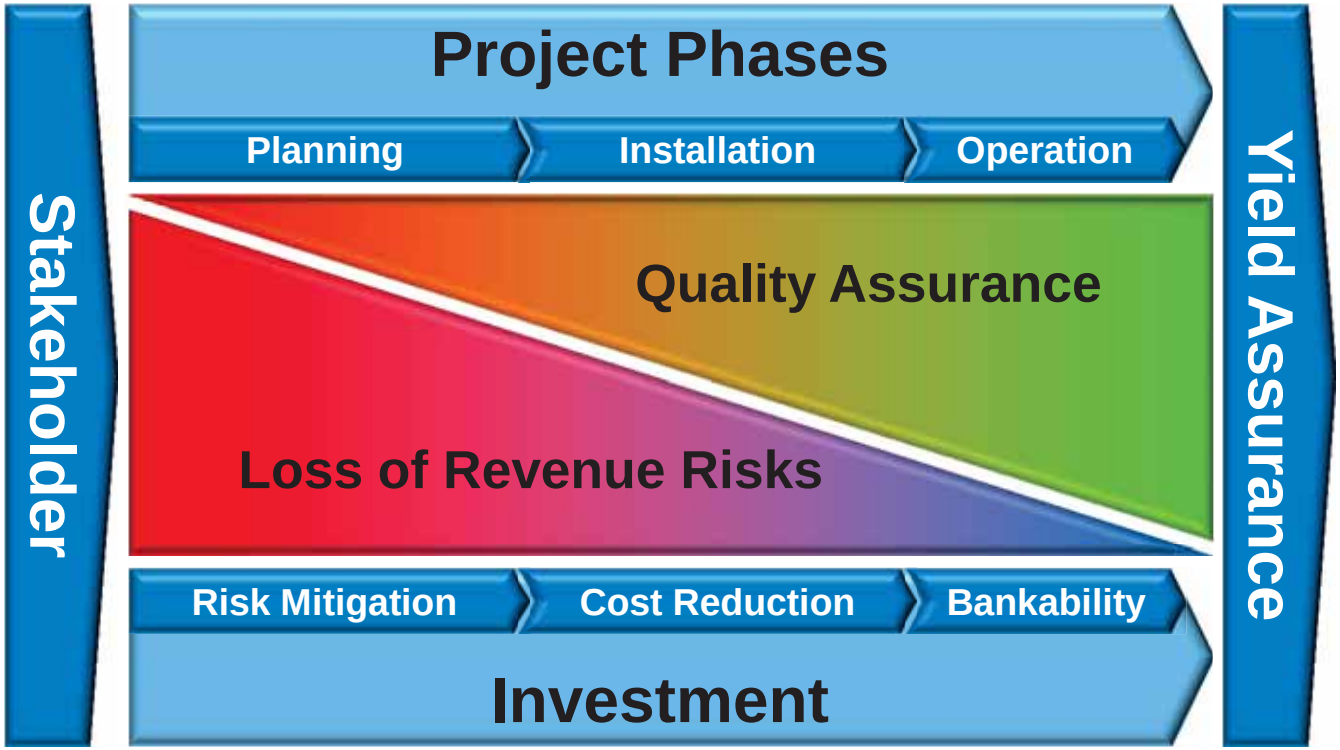
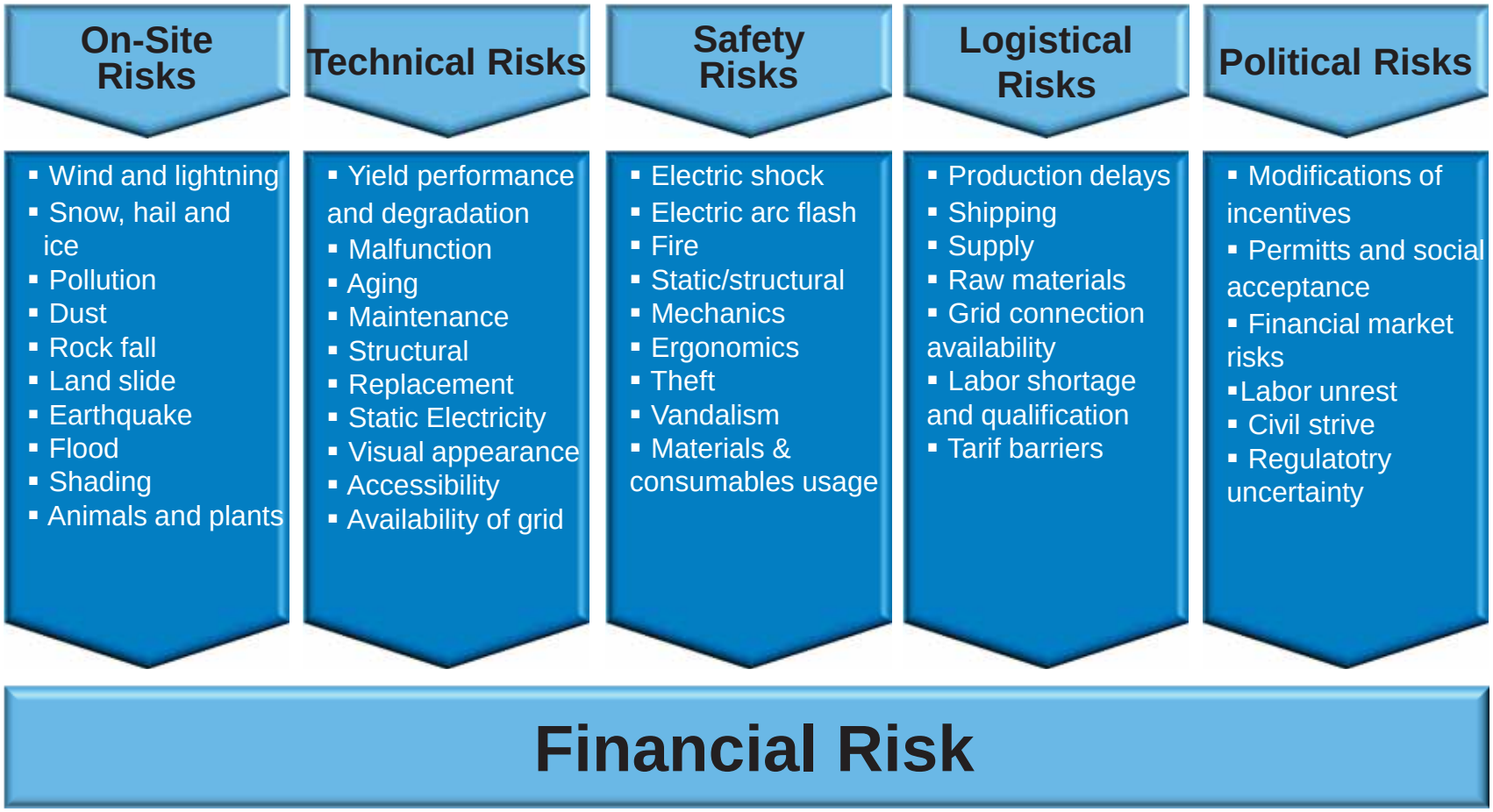
Quality Assurance for PV Power Plants



Loss of Revenue Risks
Types of Risk

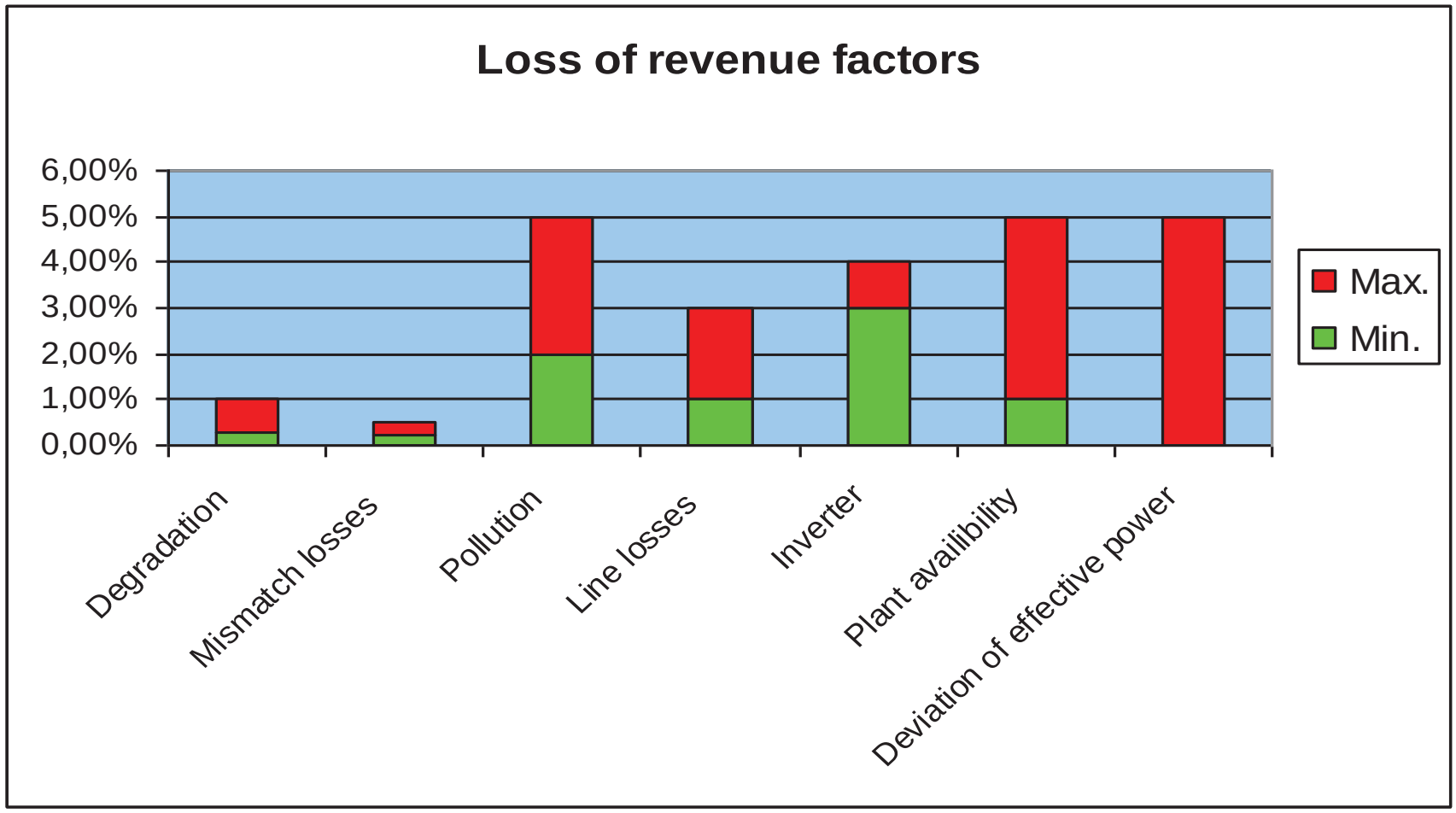


Loss of Revenue Risks
Loss of Revenue Factors 1/2

Loss of revenue factors

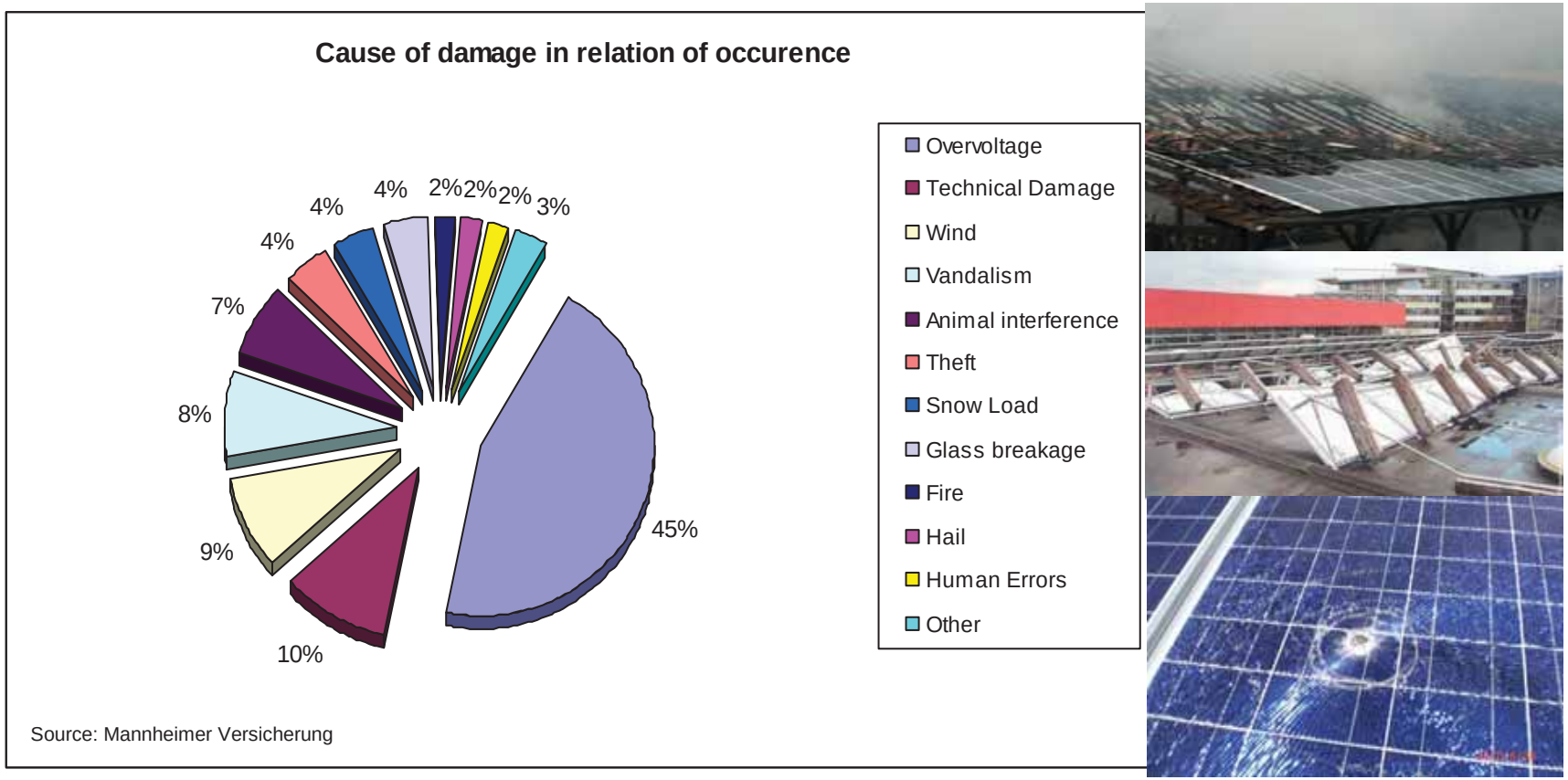
Degradation (aging related output deficit)	0.3 – 1 % / year
Mismatch losses	0.2 – 0.5 % / year
Pollution (associated with yearly cleaning)	2 - 5 % / year
Line losses (wrong dimensions or planning of lines)	1 – 3 % / year
Inverter (Ø degree of efficiency at 96%)	3 – 4 % / year
Plant availability	1 – 5 % / year
Deviation of effective power	0 – 5 % / year
Total	**7.5 % up to 23.5 % /** year

Loss of Revenue Risks
Loss of Revenue Factors 2/2



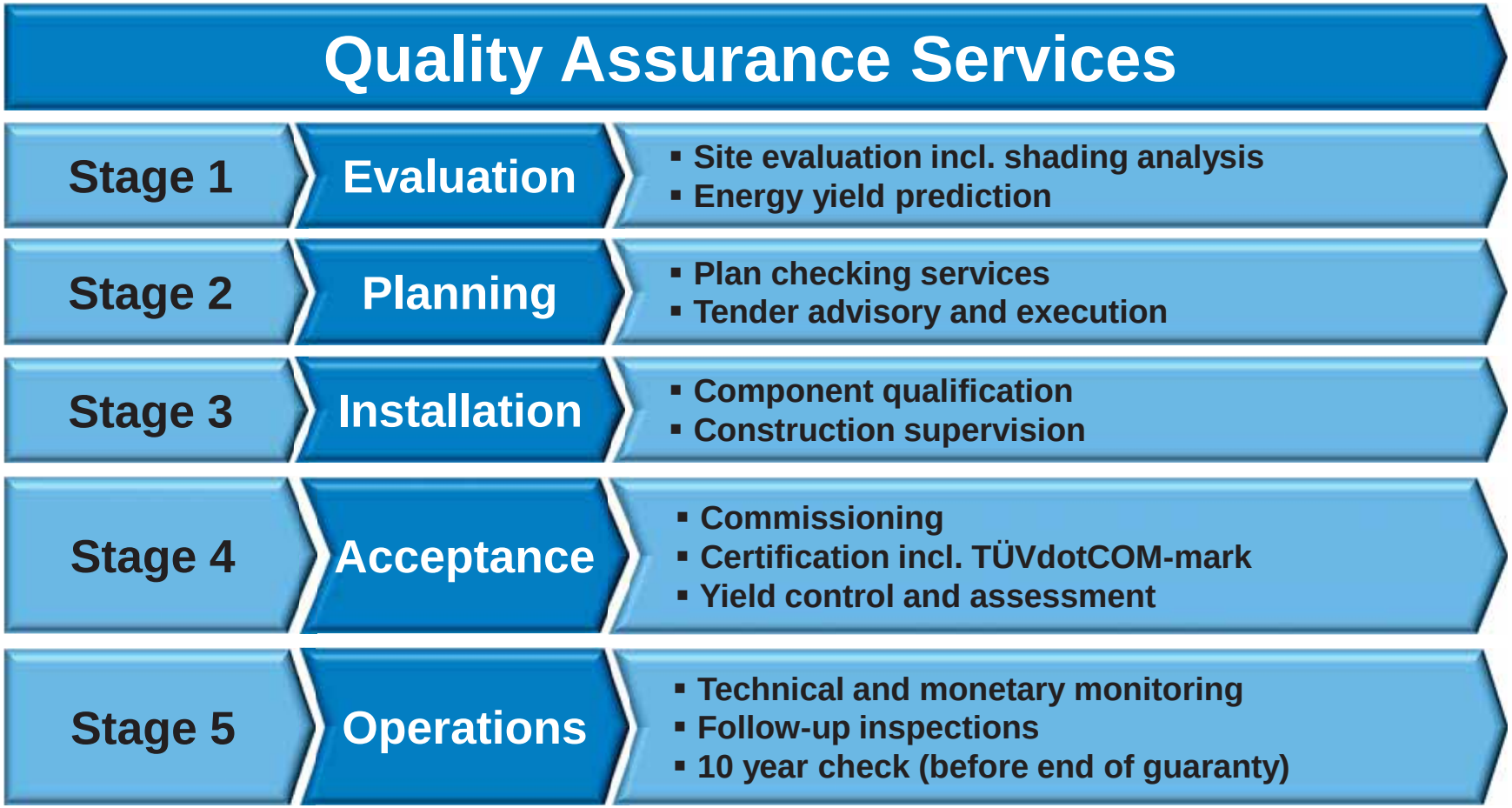
Loss of Revenue Risks

Cause of damage (Europe only – no severe weather)



Source: Mannheimer Versicherung

Quality Assurance
Overview Quality Assurance



Quality Assurance
Stage 1 – Evaluation

Meteorological Data

- Solar irradiation
- Temperatures
- Altitude
- Shading
- Wind
- Snow

Component and installation parameter

- Multivariant yield measurement
- Component parameter
- Matching of inverter, string connections, line diameter and length
- Orientation / Tracking Systems
- Shading

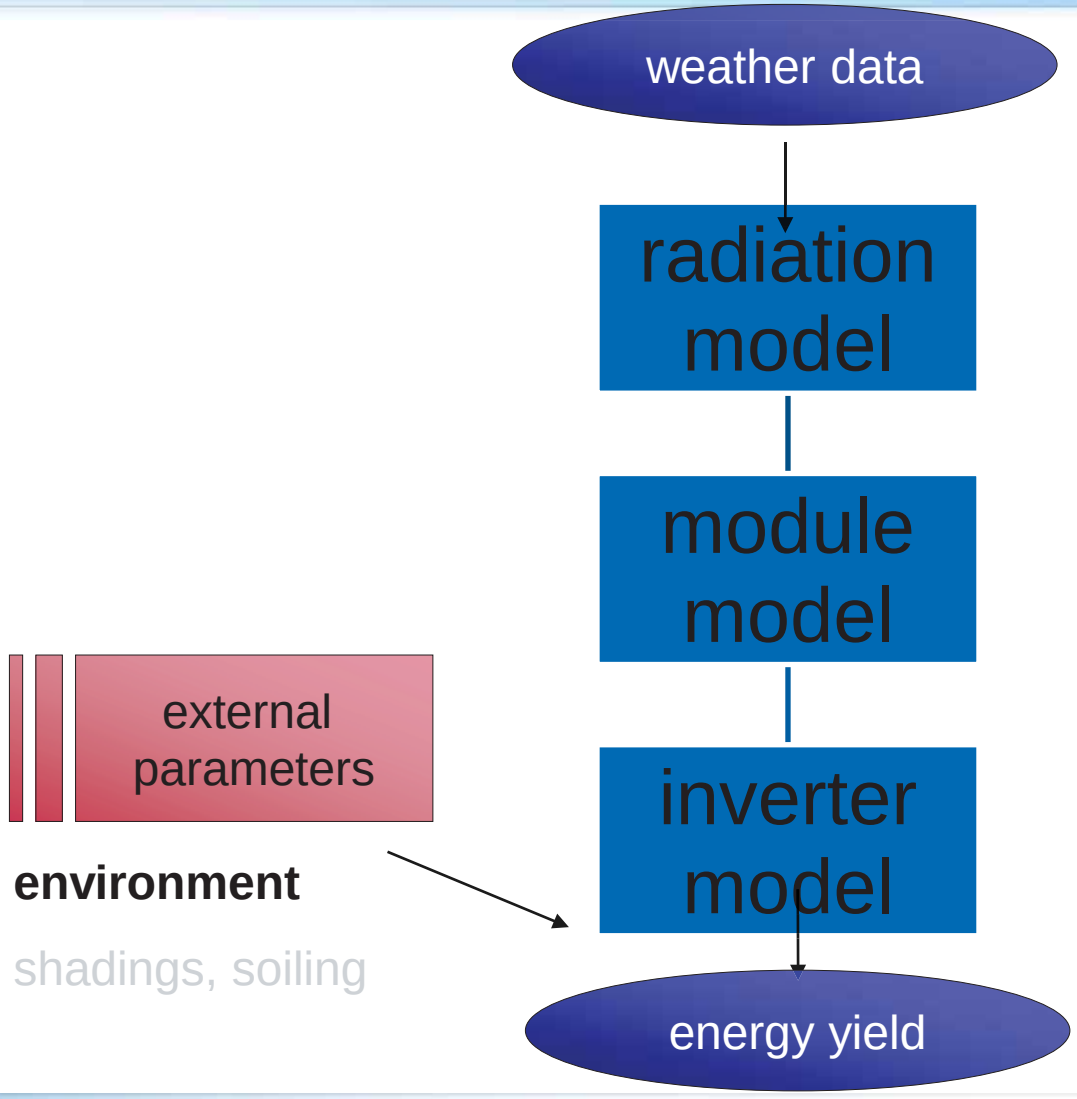
External factors

- Loss of revenue factors:
  - Pollution
  - Degradation
  - Loss factors of periphery

Calculation and simulation tools

Impartial component, site evaluation and yield prediction

Basics of Energy Yield Prognosis



temperature and radiation

measurements: ground based, remote sensing (satellite)

conversion on module plane

diffuse fraction, albedo, orientation

specific module parameters

behaviour of modules under plant specific conditions

MPP-tracking and efficiency

load range, MPP-iteration

cumulative energy

time range of inspection

Quality Assurance
Stage 2 – Planning

Assessment	▪ Calculation of solar irradiation and yield prediction ▪ Estimation of yield degradation and pollution ▪ Distance of the modules ▪ Verification of performance parameters by actual measurement
Risk analysis	▪ Lightning protection, component problems, vegetation, theft
Tender advisory	▪ Definitions of minimum quality standards for the specific components ▪ Qualified advisory services in consideration of quality standards, requirements and international standards ▪ Evaluation and weighting matrix to evaluate vendors ▪ Recommended procedures based on matrix result ▪ Neutral and independent advice

Quality Assurance
Stage 3 – Installation

Quality assurance before and during installation

Random component qualification to relevant standards

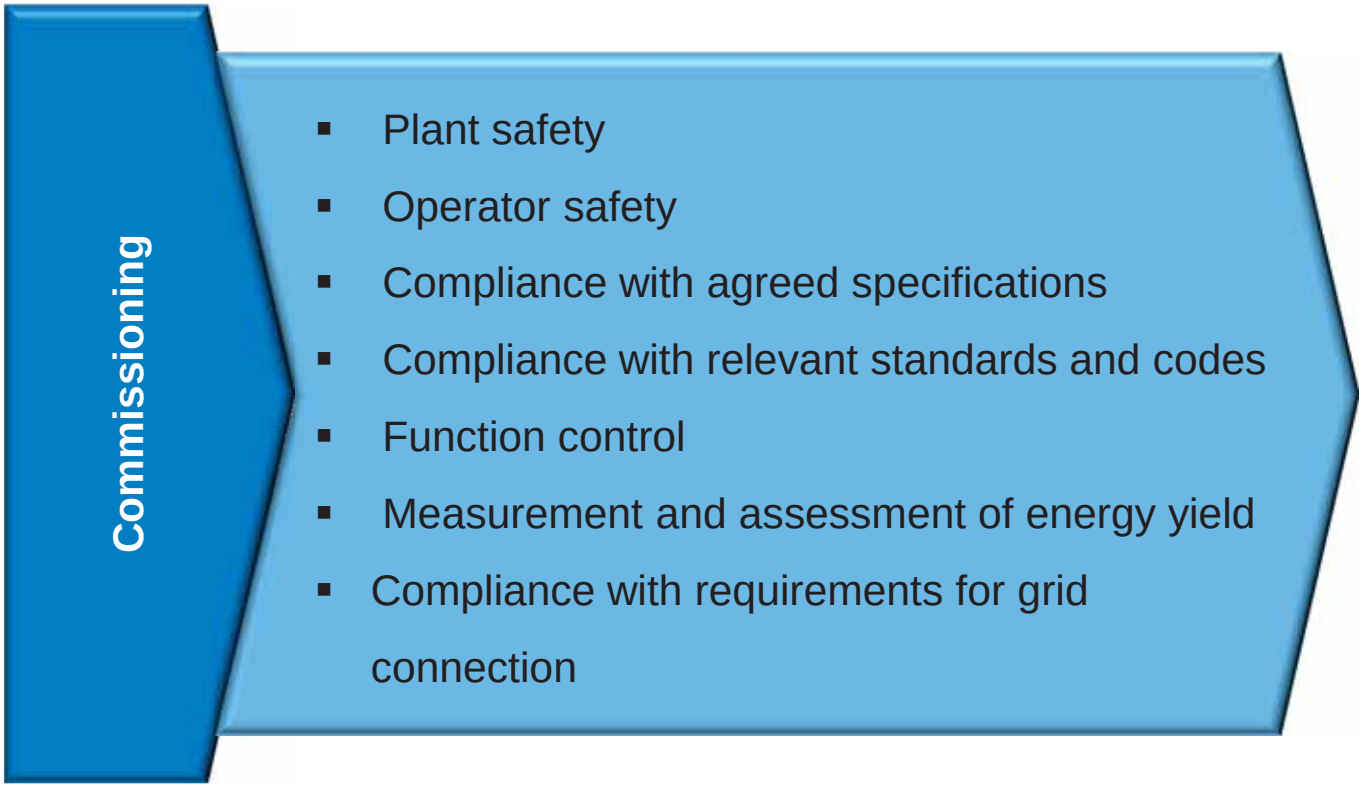
On-site supervision

Inverter
- EN 50 178
- EMV EN 61000-6-3
- EMV EN 61000-6-1
- UL1741
- TUV xxxx
- …

PV Modules
- IEC 61215
- IEC 61646
- IEC 61730
- UL1703
- TUV xxxx
- …

Early detection of deficiencies
- Wiring, interconnection
- Ground fault and short circuit safety
- General construction and PV module installation
- Lightning, fire and fault protection

Quality Assurance
Stage 4 – Commissioning



Quality Assurance
Stage 5 – Operations

Monitoring Concept

Technical Monitoring
- Continuous status control
- Collation of plant data
- Prompt fault repair
- Follow-up inspections on site
- Warranty related component inspections
- SmartGrid compliance verification

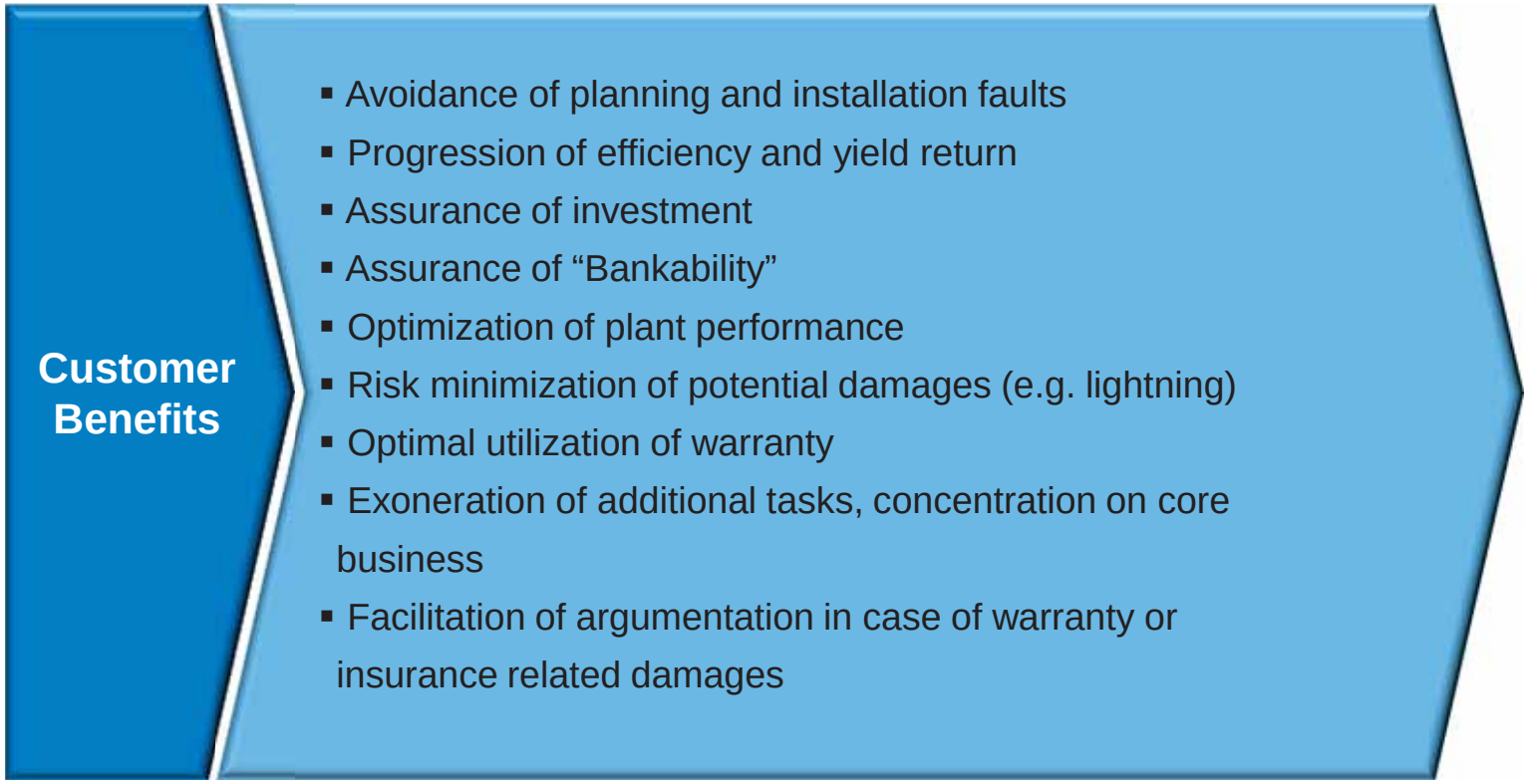
Monetary Monitoring
- Complete yield documentation
- Domain independent information integration
- Custom real time reporting
- Multi-plant integration
- Deviation analysis
- Sealed and calibrated yield data collection and web based presentation (trusted data concept)

Continuous yield control, review and assurance

Examples of low quality - projects

Examples of low quality - projects

Quality Assurance
Customer Benefits



Quality Assurance –
external inspection using the example of TÜVdotCOM approach

TÜVdotCOM

- Commissioning of the PV power plant using a predefined checklist (safety aspects, compliance with law and codes, functionality and performance)
- A unique TÜVdotCOM-ID will be allocated to your PV power plant (s), giving clients, operators, regulators or investors insight in bankability parameters. The portal can serve a number of communication functions and link to the real time monitoring.
- Periodic follow-up inspections ensure continued adherence with specifications (yearly and 3-years-inspections) and monitoring data integrity.
- Quality assurance for investors
- Ensuring “Bankability” – precise, reliable and independently audited
- The public and institutions trust TÜVdotCOM, independence and impartiality for 140 years

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Quality Assurance
TÜVdotCOM service

- Verification of energy yield
- Functionality verified
- Verified plant design
- Component specification verification/ performance and reliability tested
- Safety verified
- Measurement of string performance
- Thermography & connection verification
- Inspection of mounting system
- Inspection of lightning protection system
- Follow-up inspections

Seal with Plant-ID

Internet-Service
www.tuv.com

Enter Plant-ID

Quality information and inspection criteria:

- **Safe and compliant with laws and codes**
- **Functional**
- **Performance verified**

Additional Information:

- **Inspection certificate**
- **Links to websites of project partners or producers**
- **Inspection report, etc.**
- **Monitoring portal**

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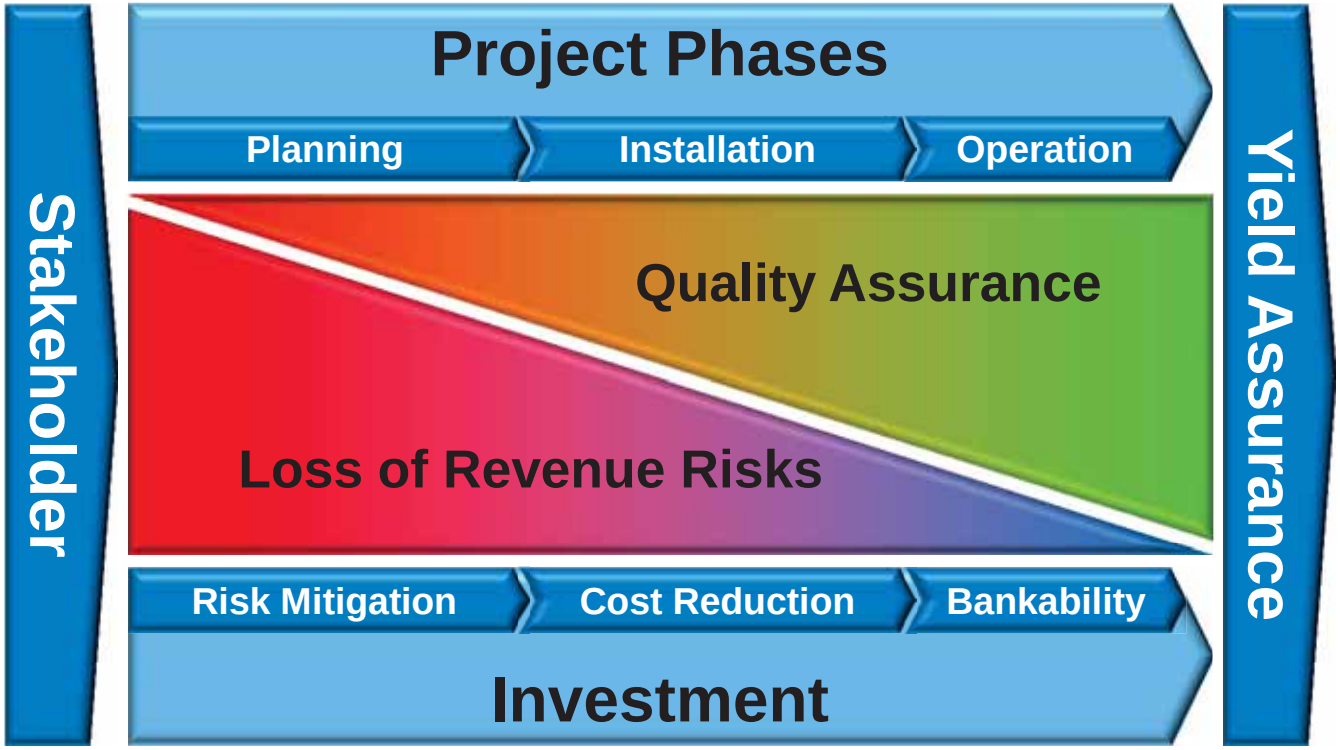
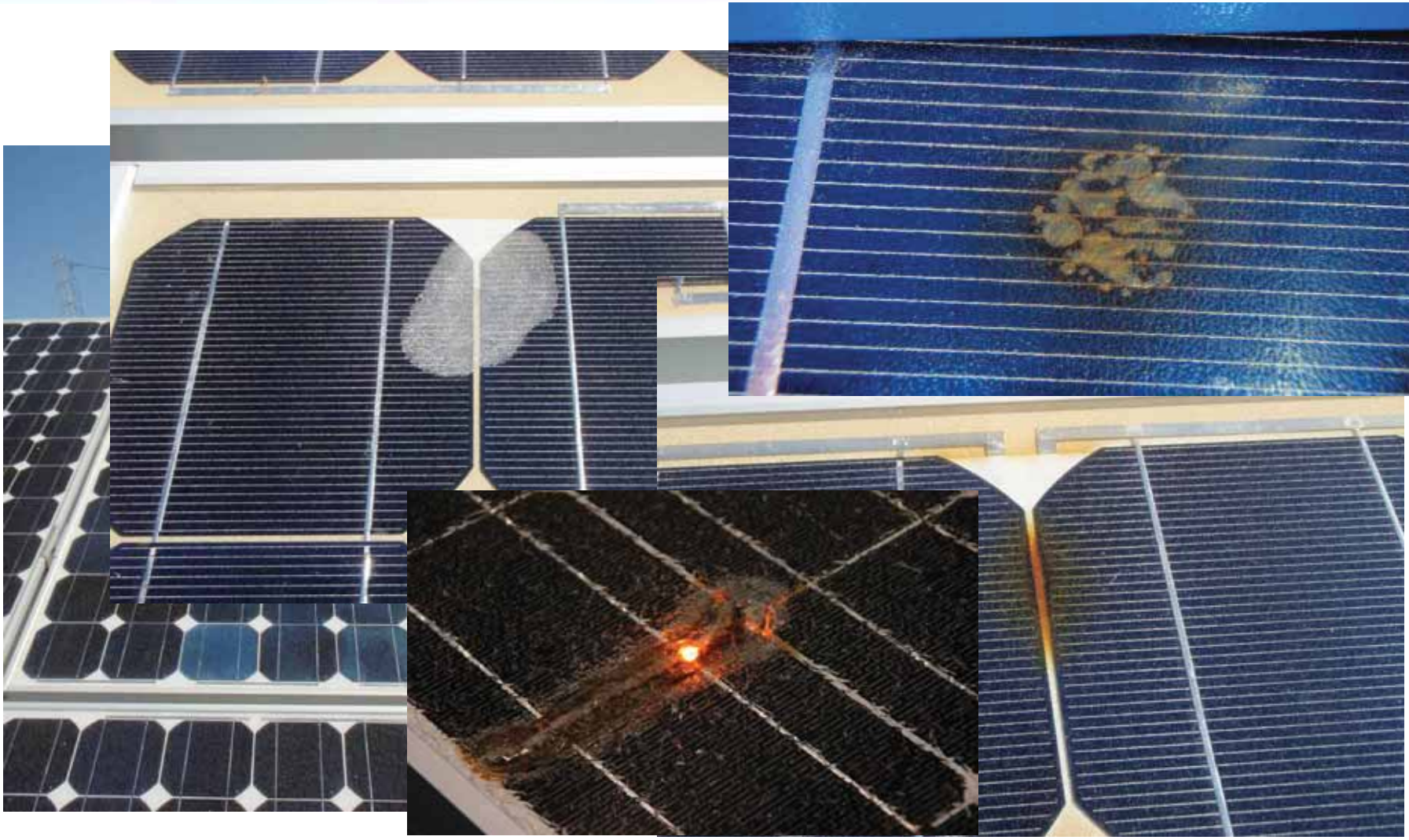
Quality Assurance for PV Power Plants

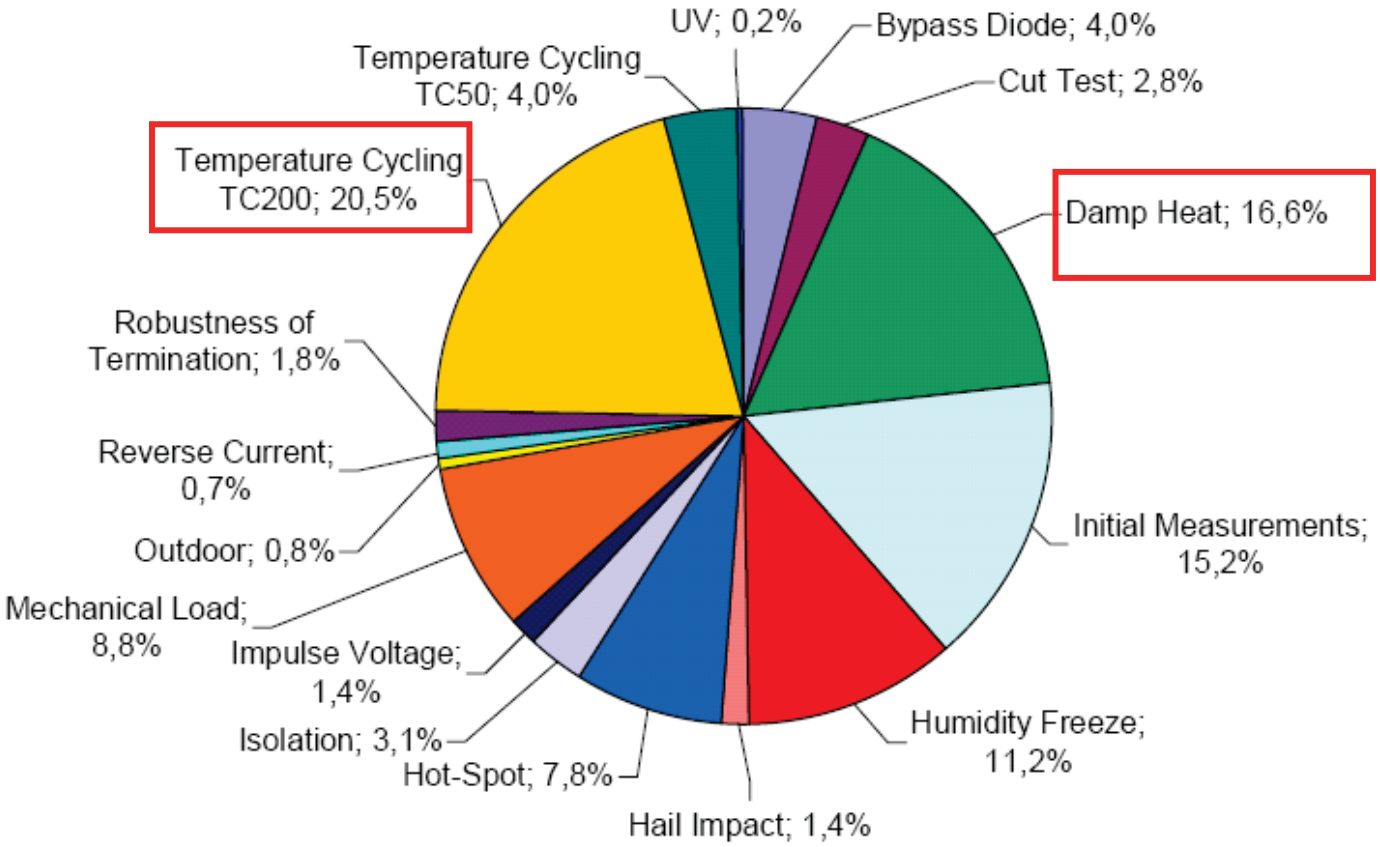


Examples of low quality – PV modules 1/2

Examples of low quality – PV modules 2/2

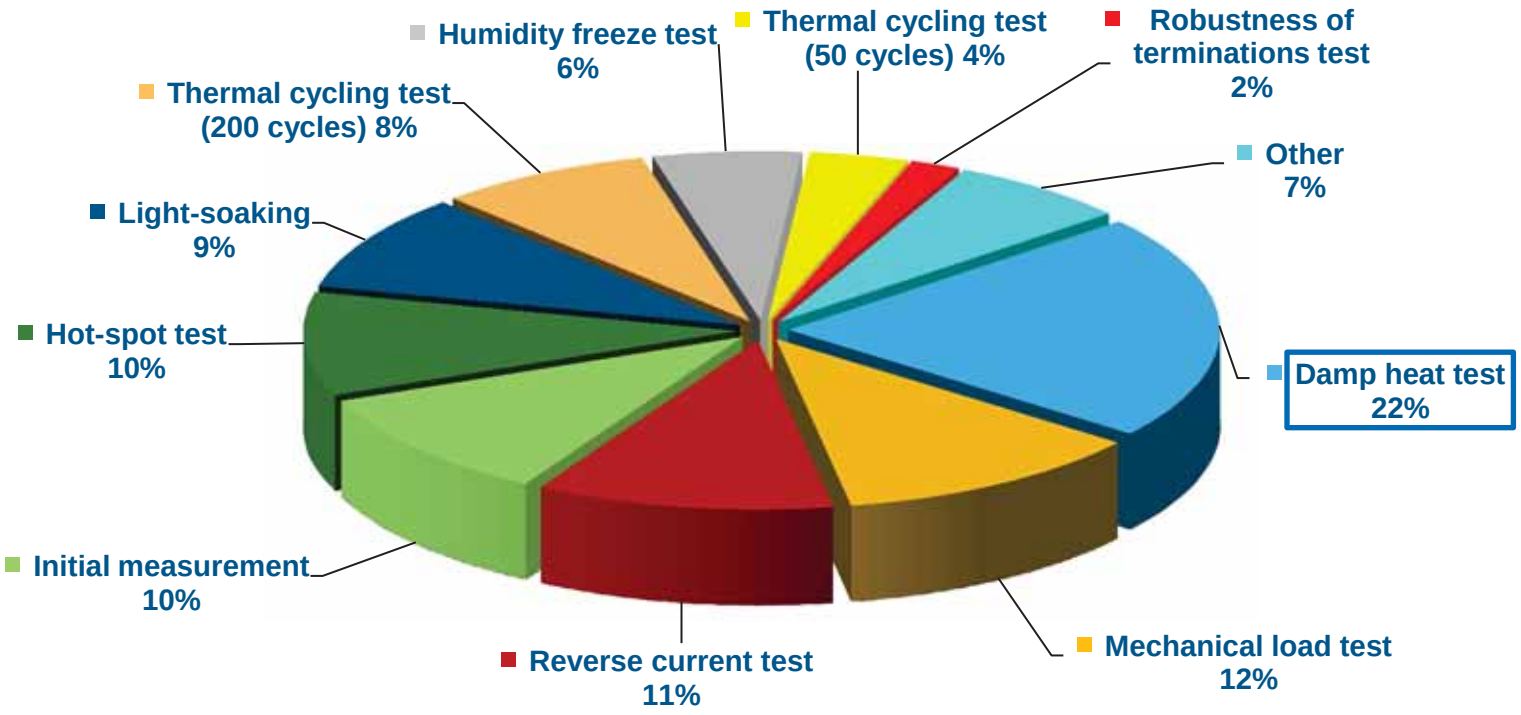


Product quality:
IEC 61215, Error distribution within the certification of crystalline PV modules



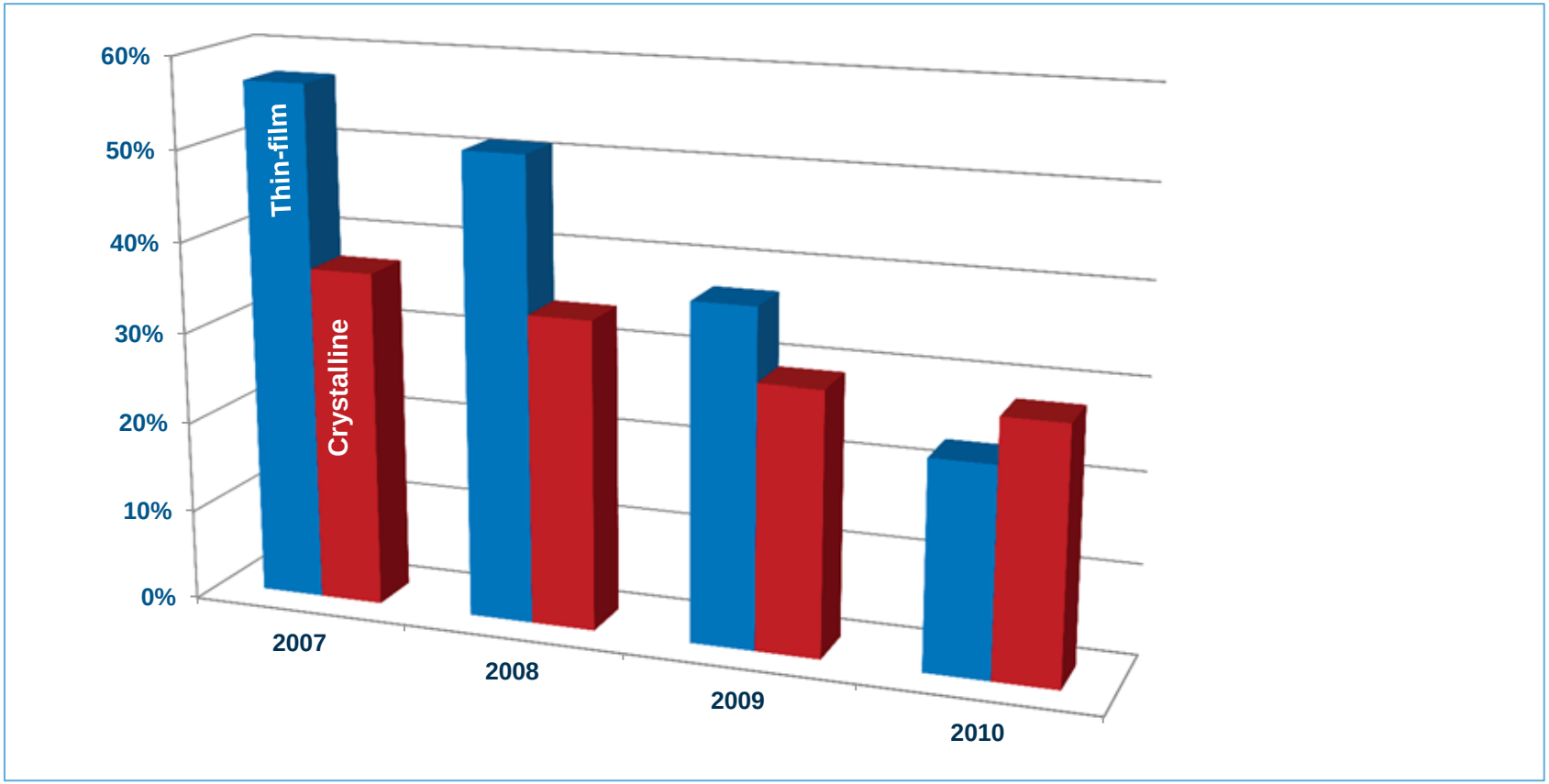
Product quality:
IEC 61646, Error distribution within the certification of thin-film PV-modules

Distribution of test failures for thin-film PV modules 2007-2011

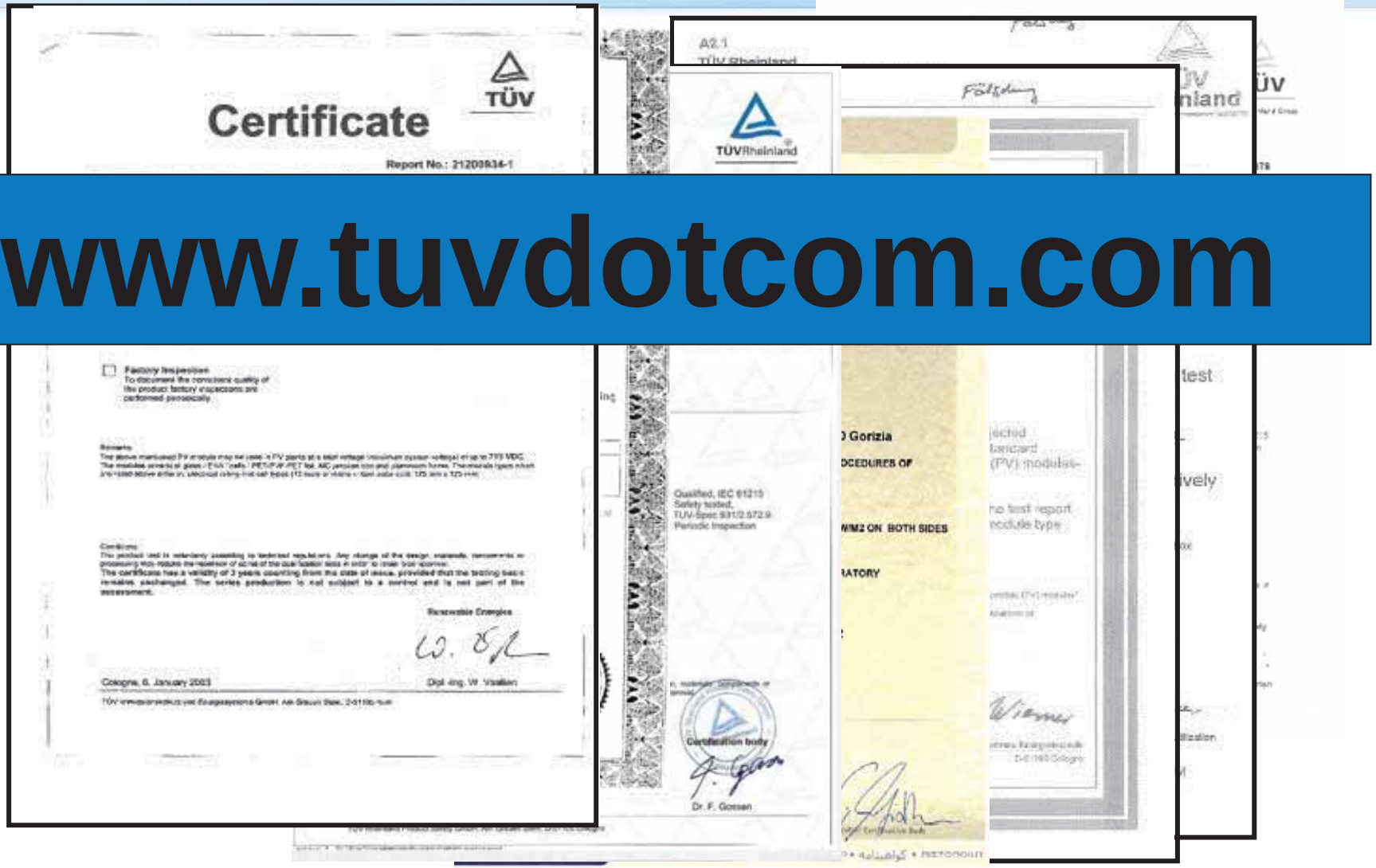


Failure rate for IEC 61215/61646 certification

Percentage of projects with at least one test failure



Check of the certificates – How to avoid fake certificates



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Summary

- Only use certified components such as modules, inverters, …
- Check the Energy yield prediction and the loss of revenue factors
- Quality control during the evaluation, planning and installation phase is the cheapest way to ensure high quality photovoltaic power plants
- Especially for bigger PV projects an external quality assurance is the best way to ensure the quality
- During the operation period active monitoring of the PV power plant is essential to detect faults as soon as possible
- Follow-up inspections during the operation period make sense to avoid safety problems and to make warranty related inspections

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