ExpoSolar® Colombia 2019

Julio 11 12 13 | Plaza Mayor Medellín Colombia

Un espacio que permite el encuentro entre la cadena de valor de la energía solar, el sector financiero y los proyectos empresariales

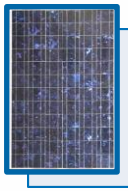
Energía renovable para **todos**

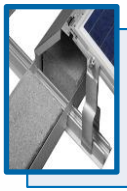
Quality management of supply chain for PV power plant

Whether you are an investor, a bank, an insurer, an owner, an operator or an EPC, is highly important to insure the control of all the supply chain so that your investment is safe!

Supply chain of PV power plant development

Development → Engineering → Procurement → Construction → Commissioning → Acceptance → Operation


PV Module


Mounting / Rack


Junction Box


PV Wire


Polymer Materials


Connector


Inverter


Storage Battery

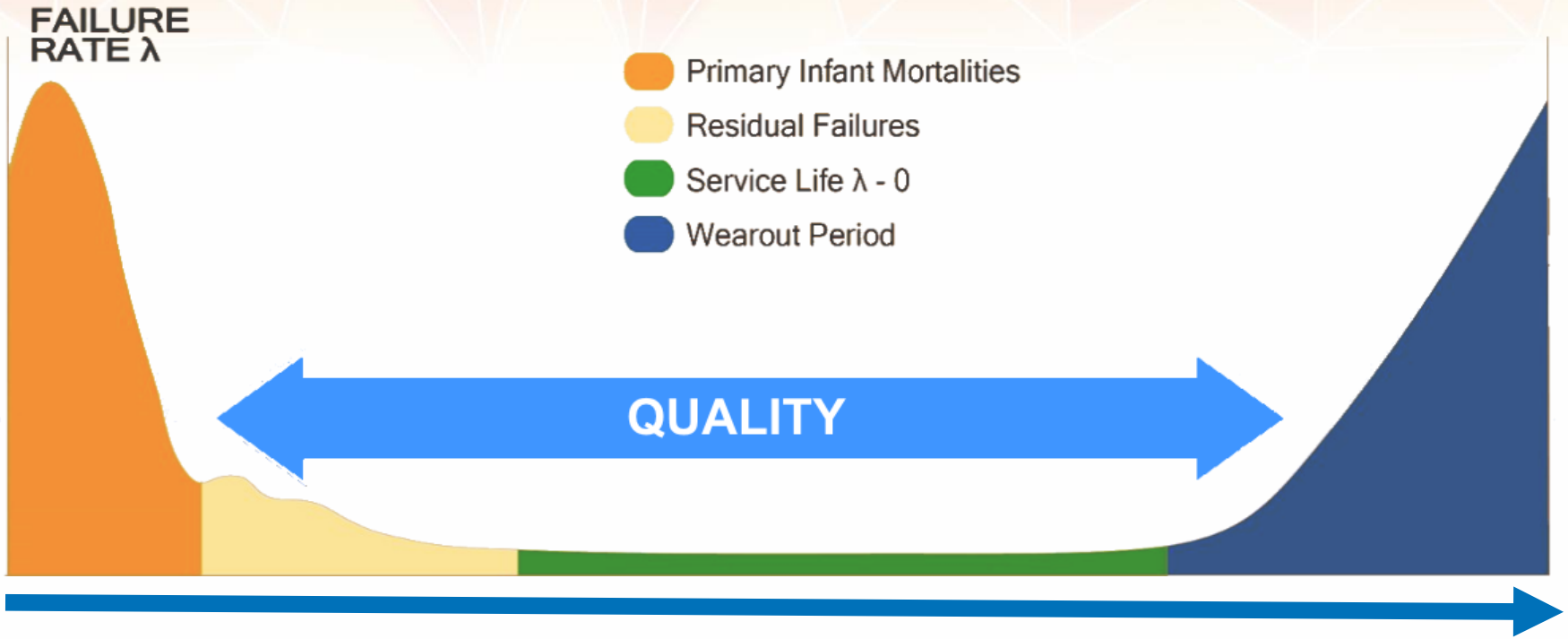

PV Fuse


PV Fuse Holder


PV Disconnect Switches


PV Circuit Breaker

Key risk factors that influence solar plant returns

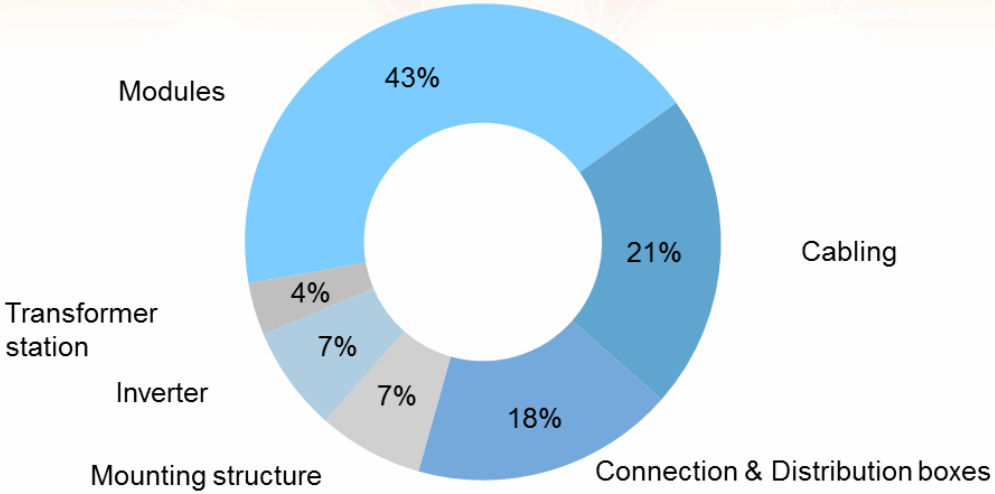


Technical Risk Matrix of PV Power Plant

Equipment	Production	Planning / Development	Installation / Transportation	Operation / Maintenance
Modules	Cell mismatch…	Shadow Diagram…	Mishandling…	Hot Spot…
Inverter	MPPT Issues…	Inverter Wrongly Sized…	Unstable Installation…	Low Performance…
Mounting Structure	Mounting Structure Corrosion…	Roof and Static Analysis missing…	Screw not fixed…	Damage During Maintenance Work…
Connection & Distribution Boxes	Material Incompatibility…	Wrong Sized Cable Gland…	Lack of Strain Reliefs…	Missing Protection…
Cabling	Broken Connector…	Cable undersized…	Different Type of connectors…	Cut, Pressed and/or Broken Cables…
Grounding	Wrong Materials…	No grounding system…	Grounding missing…	Broken grounding…
Weather Station	…	Shadow and Soiling of irradiance sensors…	Misalignment between the solar irradiance sensors and Array…	Damaged Sensors…
Transformer	…	Cabin Doors not grounded…	Missing Labeling…	Wrong Transformer Configurations…
Storage System	Low quality storage system…	Battery Wrongly Sized…	Storage system in not ideal environment conditions…	Operation Problem with PV inverters…

Result of an internal study: Failures/defects in power plants

Particularly serious defects in PV Power Plant 2014/2015

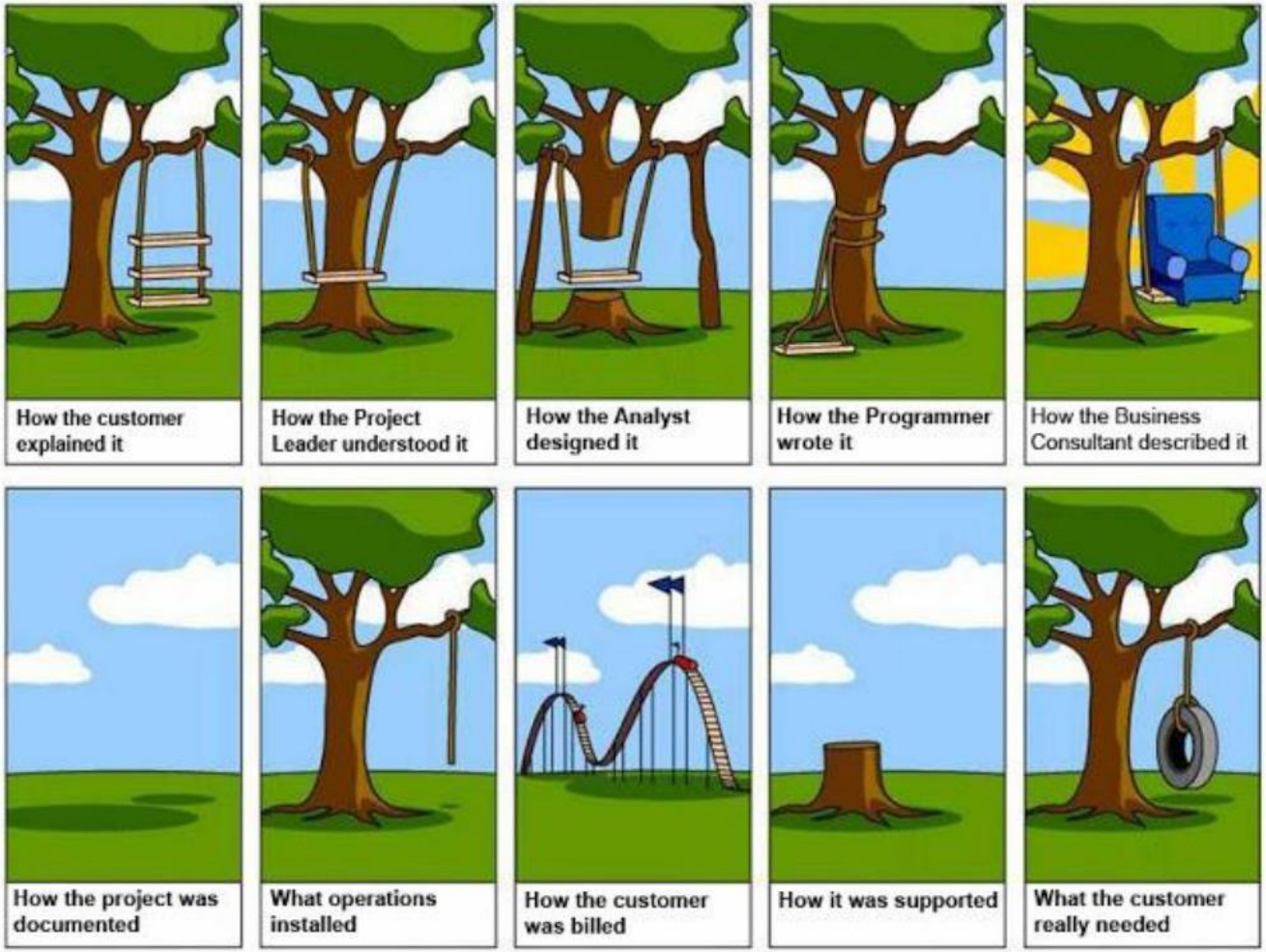


Examples for particularly serious defects	(Needs immediate action)
Connection & Distribution boxes	Missing Cover (no protection against electric shock)
Modules	Glass breakage, Burned junction box
Inverter	Inverter out of operation
Mounting structure	Risk of mechanical damage
Cabling	Damaged Cable, Connector burned down
Transformer station	Panic lock blocked

Technical Risk Matrix of PV Power Plant

Equipment	Production	Planning / Development	Installation / Transportation	Operation / Maintenance
Modules	• Incorrect Soldering • Cell broken • Cell mismatch • Cell overlap • Bubbles • Undersized bypass diode • Junction box adhesion • Delamination at the edges • Visually detectable hot spots • Failed insulation test • Failure on mechanical load • Defective label solar module • PID • Lack of certification • Incorrect Power Rating	• Glass breakage • Soiling losses • Shadow diagram • Modules mismatch • Modules not certified • Flash test report not available or incorrect • Modules weight • Mechanical resistance • No protection against reverse current • Different types of modules • Lack of experience in the field • Special climatic conditions not considered(salt corrosion, ammonia,..)	• Module mishandling (Glass breakage) • Module mishandling (Cell breakage) • Defective backsheet • Soiling • Breakage during transport and installation • Modules fixing system • Module frame damage • Module plug connectors substituted • Incorrect connection of modules • Short circuit or defect at modules	• Hot Spot • Delamination • Glass breakage • Soiling losses • Shading losses • Snail track • Cell cracks • Defective backsheet • Overheating junction box • PID • Failure of bypass diode and junction box • Corrosion in the junction box • EVA discoloration • Module degradation

Quality management of supply chain for PV power plant development



What are the problems:

- information asymmetry
- inconsistency

Quality management of supply chain for PV power plant development – Examples

（1）太阳能电池组件产品必须通过 CE、莱茵 TUV、UL、鉴衡、CQC 等相关国际国内认证，并符合国家强制性标准要求。每块组件出厂前应有工厂测

（10）光伏组件防护等级不低于 IP65。

卖方供货组件应通过加严环境试验。

3.5.11 卖方供货组件使用工业防水耐温快速接插件，接插件防锈、防

等性能要求，接插件的物理特性和电性能符合 GB/T 20047.1-2006 的要求，

连接线规格：4mm^2×1000mm（长度根据电站设计要求），连接器兼容 MC4

Problems:

- Wrong standard
- Wrong requirement
- Unclear specification
- Cannot be verified

Cost of Poor Quality (COPQ)

Warranty

Inspection

Field Service

Yield

Gross Margin Erosion

RMA

Rework / Re-grade

Rejects / Scrap

Visible Costs

Engineering change orders

Lost sales / opportunities

Late delivery

Time value of money

Expediting costs

More Set-ups

Excess inventory

Working Capital allocations

Long cycle times

Hidden Costs

Lost Customer Loyalty

Degraded Brand Image

Excessive Material Orders/Planning

COPQ ranges 15-20% of total cost! Hidden costs can be up to 4 times the visible costs!

Source： Govind Ramu - SunPower Corporation

Quality management of supply chain for PV power plant development – Example equipment failures

Foundations

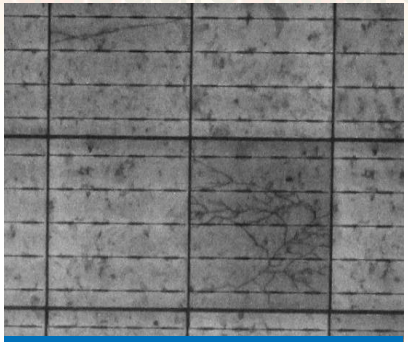
Rack

Connector

Substrate

PV Module Product Quality - Examples for PV module failures

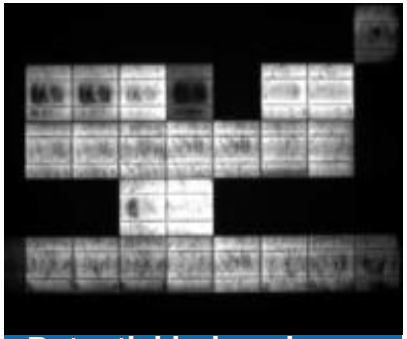

Glass breakage

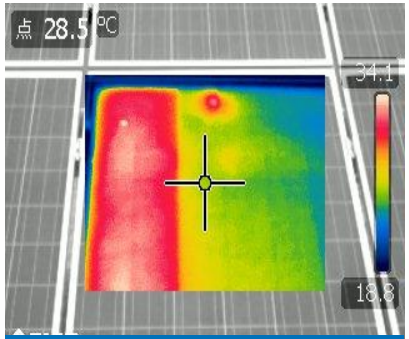

Cell cracks


Delamination

Frame breakage


Junction box failure


Potential induced degradation

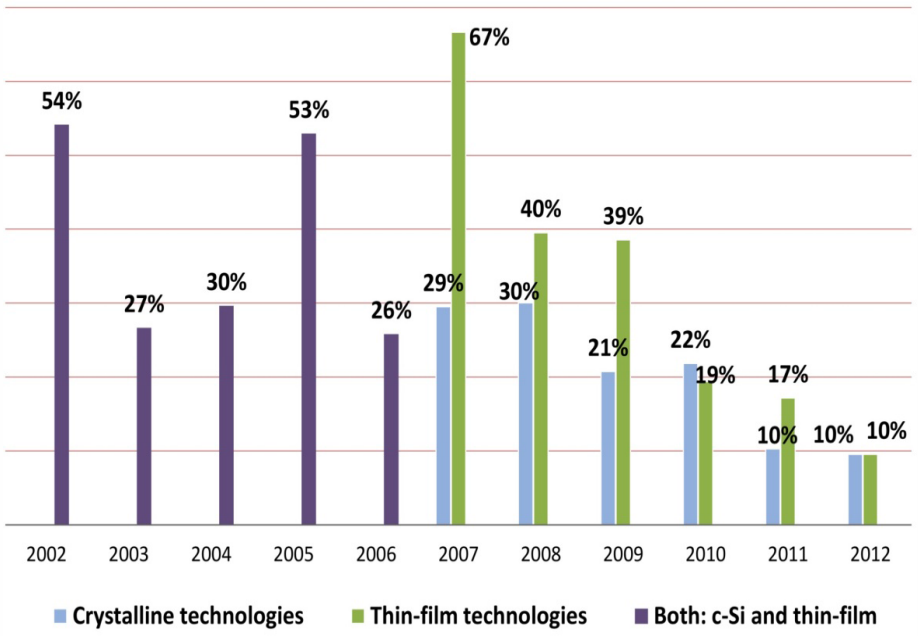


Bypass diode failure

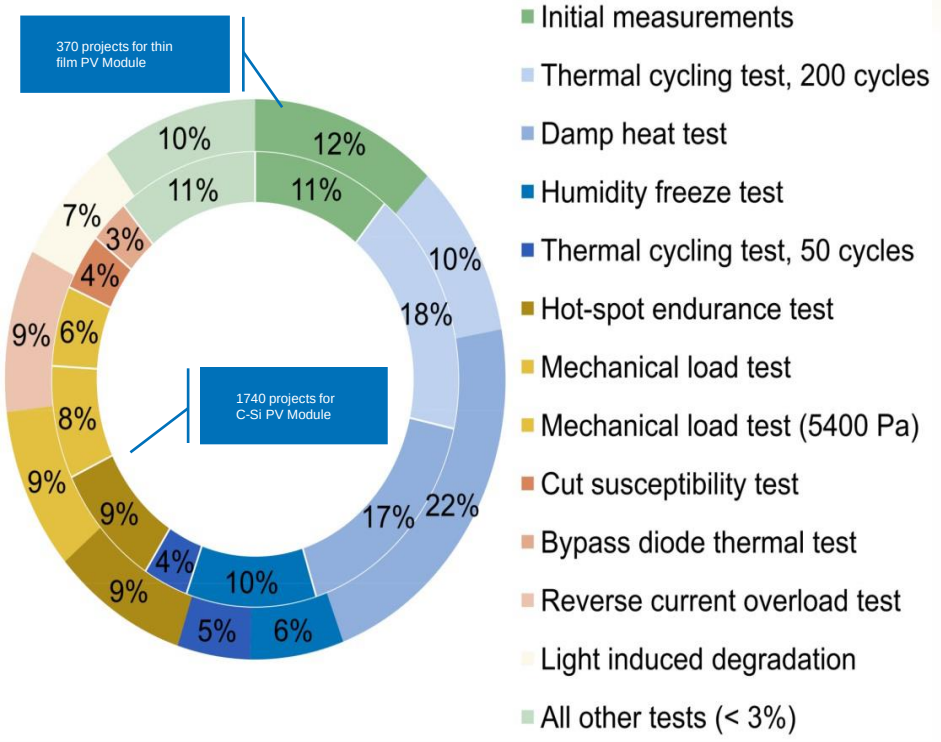

Safety issues

PV Module Product Quality – Failures in Testing

TÜV Rheinland has analyzed a total of 2000 certification projects conducted at the Cologne Solar Testing Centre from 2002 to 2012.



Annual percentage of failure in IEC projects.

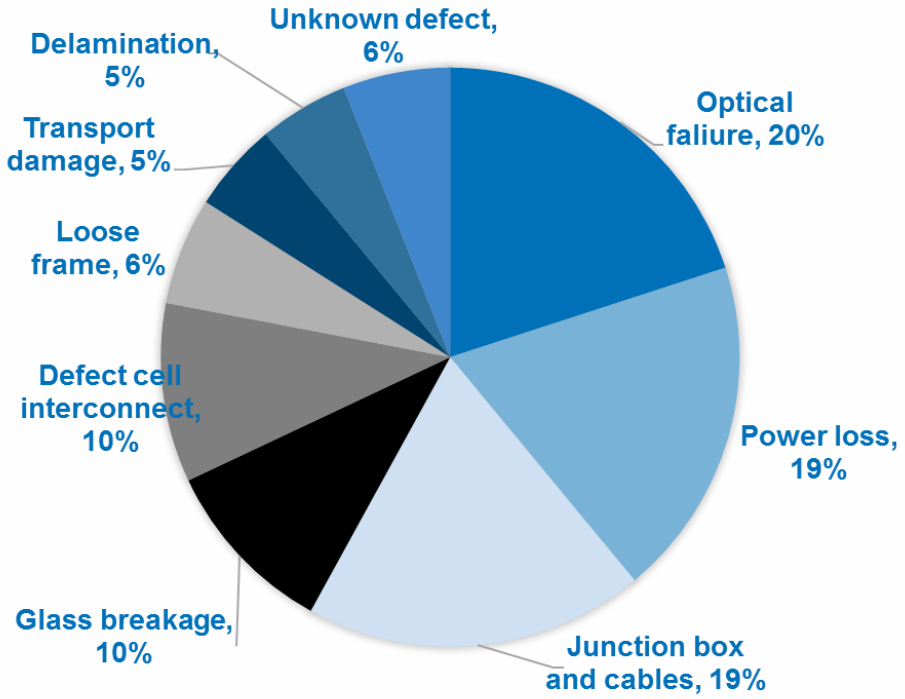


Distribution of failures in IEC projects from 2006 to 2013.

Source: IEA PVPS 2014

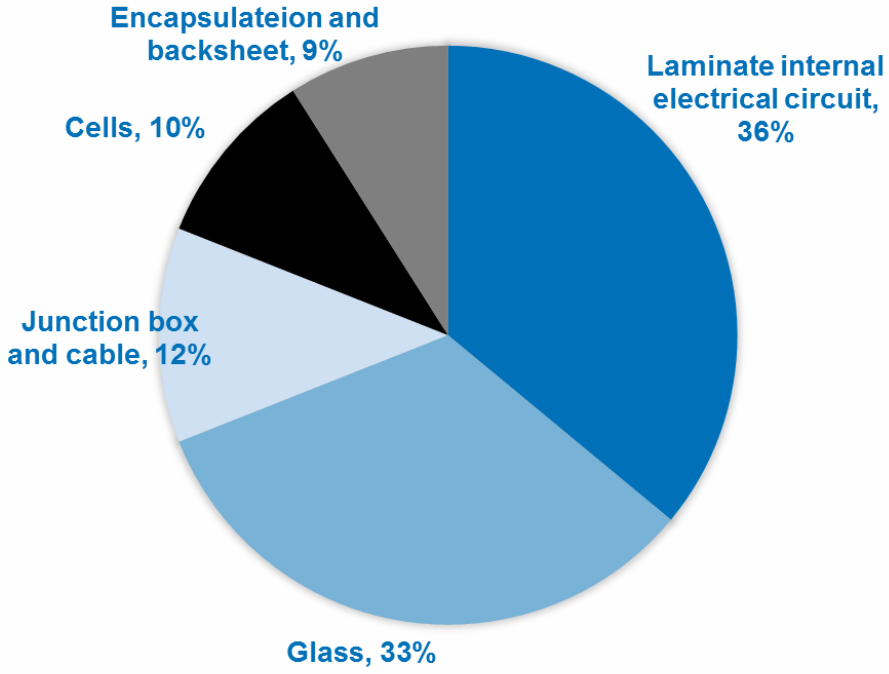
PV Module Product Quality – Failures on Site

Failure rate from warranty claims (2011~2013)



Source: IEA PVPS 2014

Failure rate from field studies (8 years, 21 manufacturers)

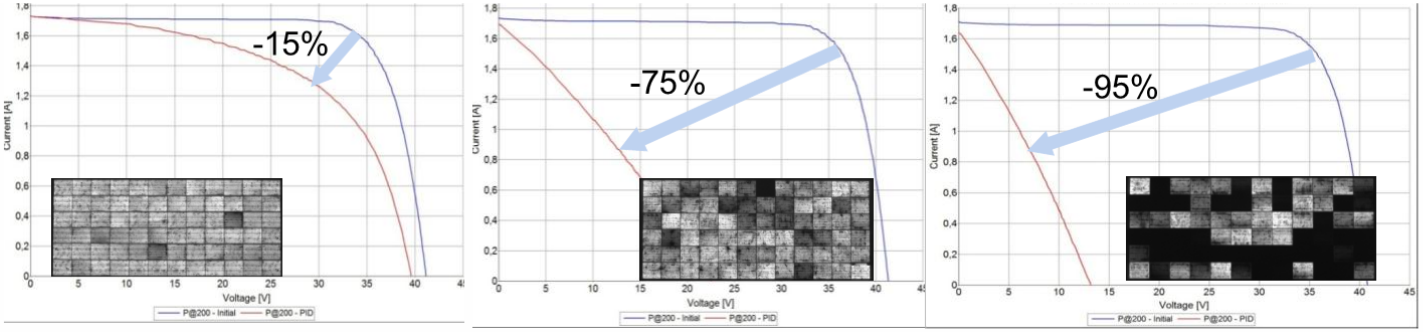


Source: IEA PVPS 2014

PID- Performance killer number one

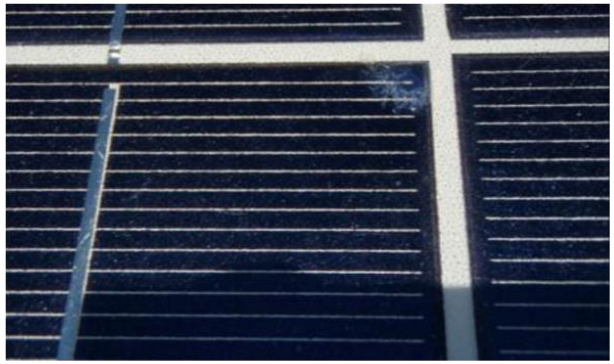
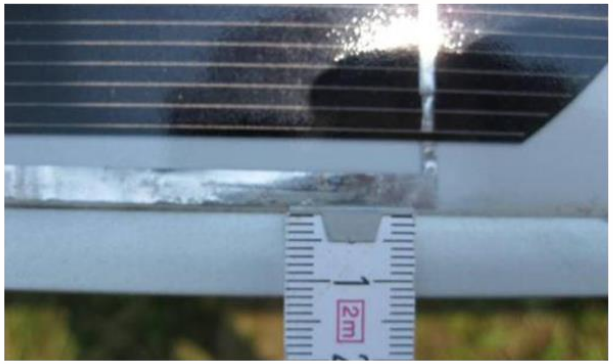
- Potential induced degradation (PID)
  (occurs in cases of high voltage, sensitive module/material combinations and damp environments – e.g. caused by condensation, high humidity)
- Reversible process through grounding or counter-potential (investments required)
- Knowledge of PID sensitivity of PV modules is necessary

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



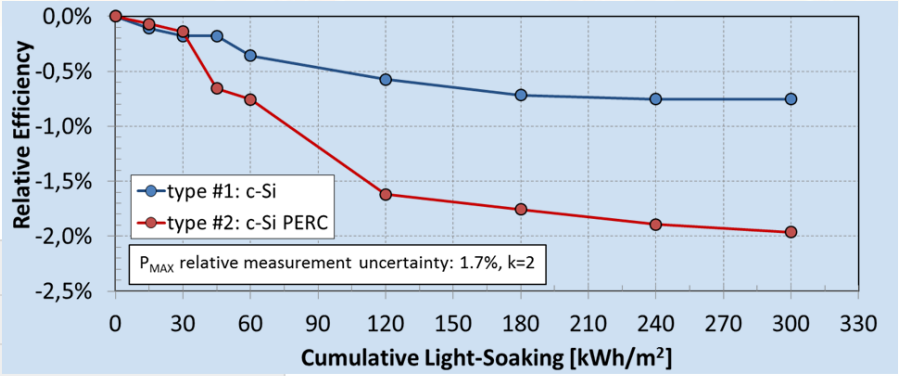
! All material combinations of a module must be considered in order to declare it PID-resistant!

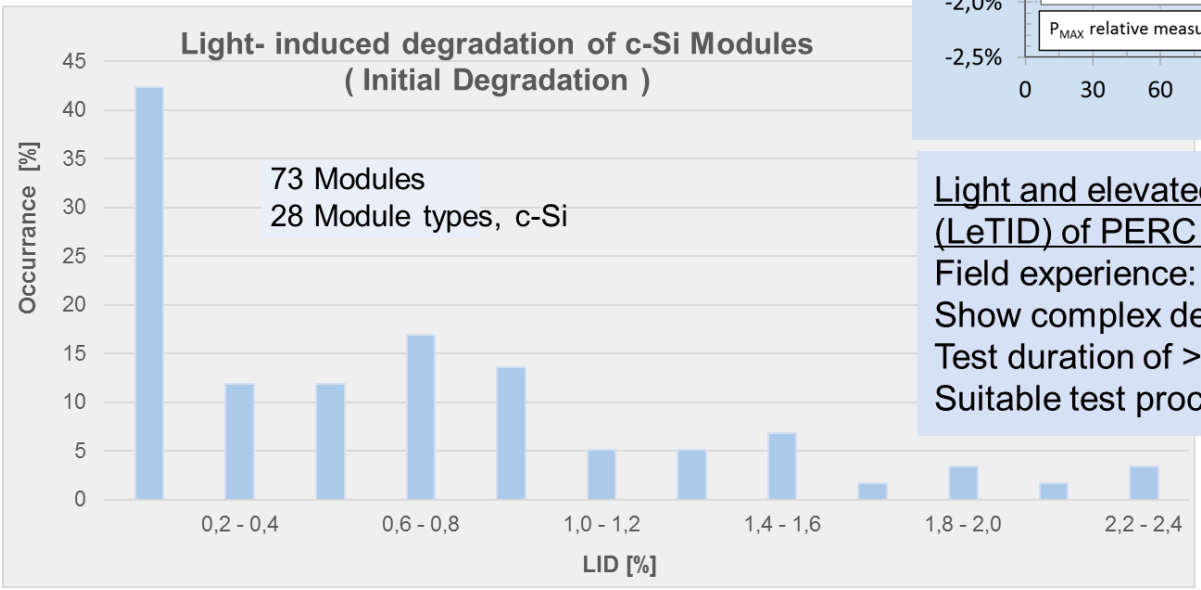
Module failures in the field



Initial Degradation





Light and elevated Temperature Induced Degradation (LeTID) of PERC Modules:

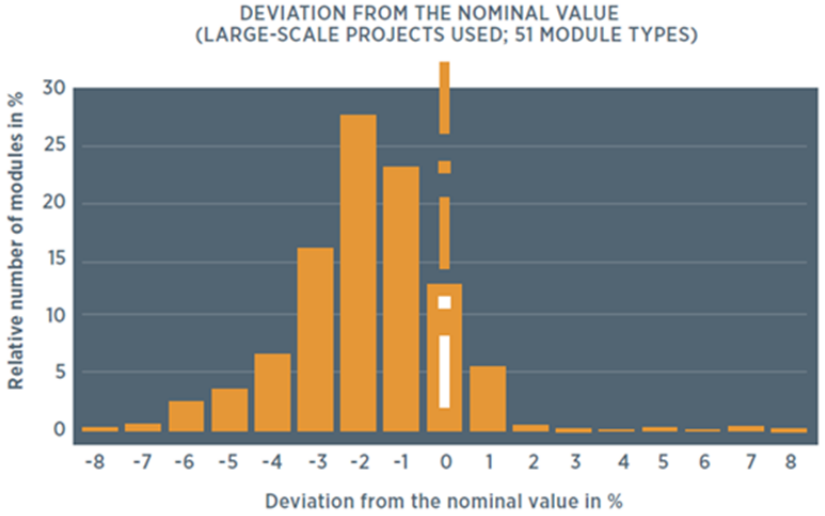
Field experience: Up to 6% degradation

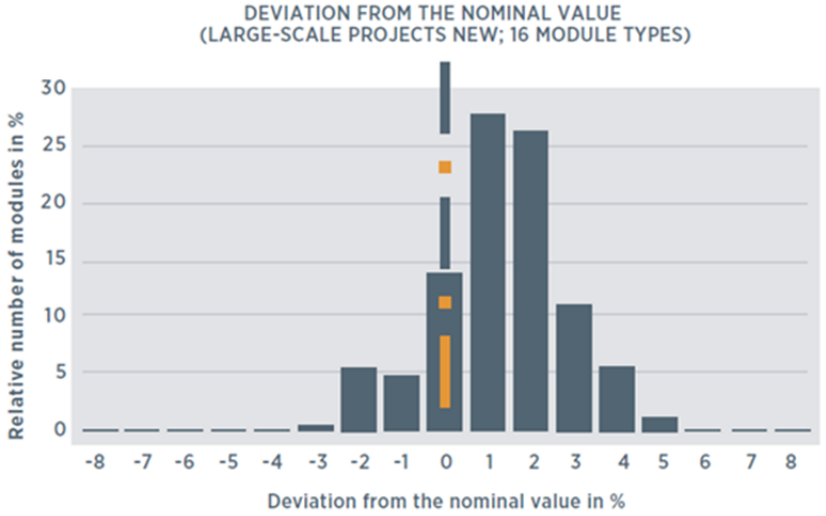
Show complex degradation- regeneration processes

Test duration of >100 h

Suitable test procedure under discussion

Wrong power classification!





! Left: Module Manufacturer were not aware of independent measurement
Right: Module Manufacturer has been informed about independent measurement

Example:
One percent power deviation of a 100 MWp PV power plant (investment 100 Mill €) can lead to 3 Mill € revenue losses

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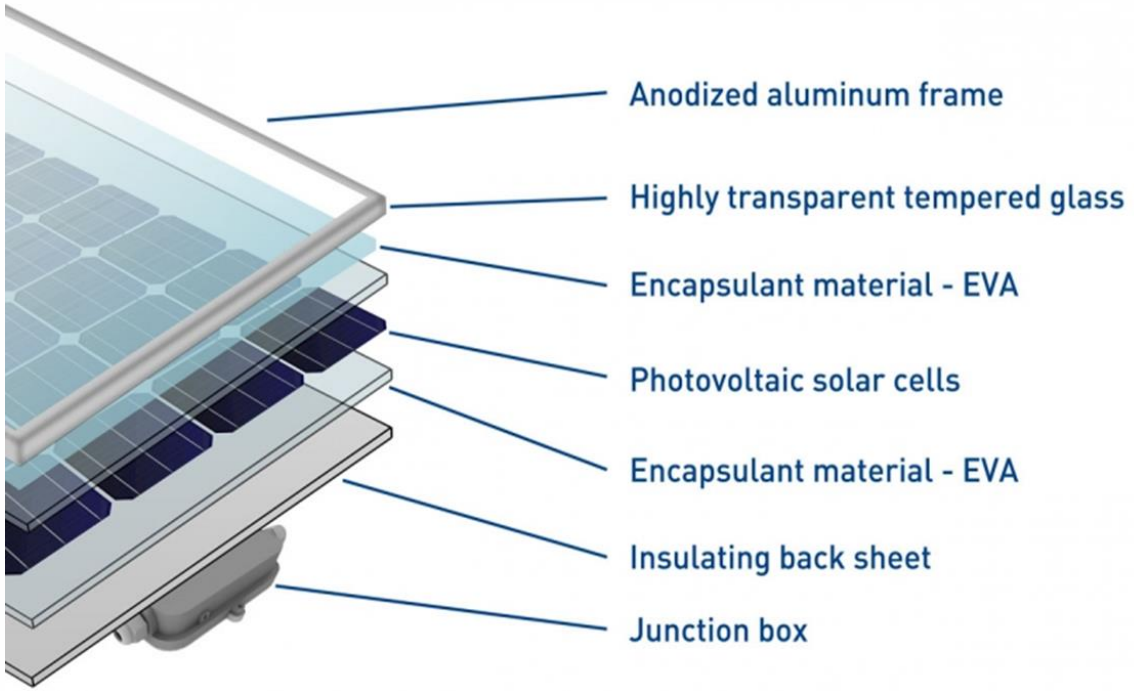
PV Module Product Quality

Potential defects can be defined during visual inspection



Bend, broken, scratched, misaligned
Visibly cracked or broken by naked eye, scratch, bubbles, cleanness
Bubbles, delamination, yellowing, browning
Broken cell, cracked cell, discolored anti reflection, burned, oxidized, soldering, position
Delaminated, bubbles, yellowing, scratches, burn, bump, sealing
Loose, oxidation, corrosion, Detachment, brittle, exposed electrical parts

QC Along the Buyer Sourcing Supply Chain

- **Development**
  - ❑ Concept for supply chain management;
  - ❑ Assessment of the production facilities and each manufacturer
- **Pre-production**
  - ❑ Potential supplier auditing and selection;
  - ❑ PV module quality and performance testing
- **Production**
  - ❑ Testing during production on a spot-check basis;
  - ❑ Quality and performance confirmation
- **Post-production**
  - ❑ Inspection before and after shipment;
  - ❑ Pre-installation testing

Pre-Production Factory Inspection

Evaluation for the Overall Order

Product Certificate	Equipment	Procedures	Quality Control
Production Process	Documentation	Faulty products	Finished products

Nonconformities in Pre-production Period

Typical findings

- Manufacturer assessment
  - ❑ Production facilities -> low level of automated lines
  - ❑ Capacity assessment -> order change / breach
  - ❑ Personnel assessment -> inadequate training
  - ❑ Warranty claims assessment -> inadequate response
- Product assessment
  - ❑ Raw materials not in BOM or CDF -> uncertified modules!
  - ❑ Serial no. encoding -> concealing real production info.
- Production line verification
  - ❑ Verify production in agreed factory/workshops -> unapproved OEM factory of uncertified factory
  - ❑ Quality assurance -> poor quality management in production process

During-production (DuPro) / Pre-shipment Factory Inspection

Assurance on Each Shipment

Manufacturing Lines	Material (BOM)
Quality Management in Production process	Verification Tests (flash, EL, safety, etc.)
Packaging	Storage

DuPro Inspection /Surveillance

- Daily routing inspection
- Yield supervision
- Final product daily verification

Pre-shipment Inspection

- Production line spot check
- Final random verification
- Loading operation

Sent to TÜV Laboratory for further verification

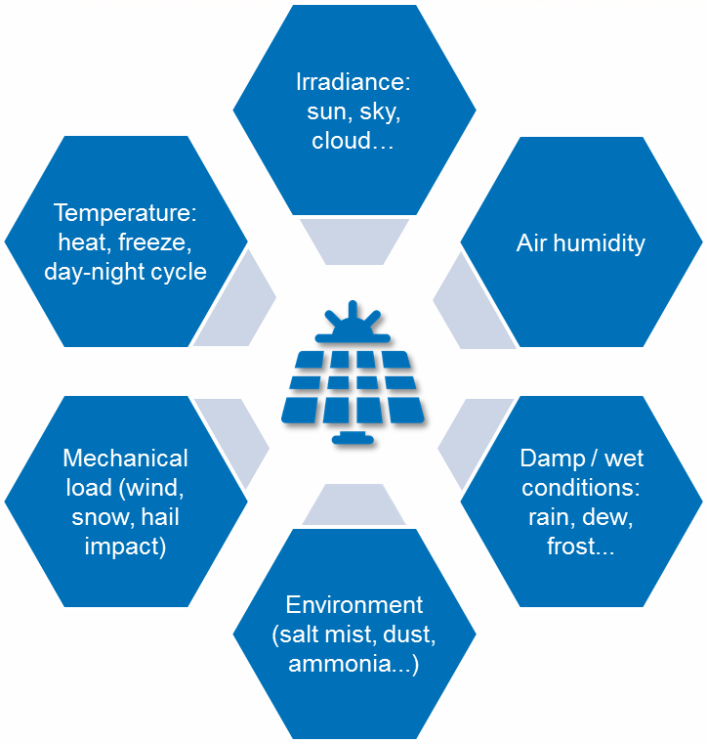
Nonconformities in Production Period

Typical findings

- Material management
  - ❑ Incoming material -> lack quality control/ testing for materials
  - ❑ Inline material -> different from ordering records/ contracts
- Production line verification
  - ❑ Process -> not conform with Standard Operating Procedure
  - ❑ Personnel -> misconduct/ be asleep at duty
  - ❑ HSE -> high risk of accidents
- Final products defect findings
  - ❑ Appearance -> visual inspection
  - ❑ Maximum Power -> Flash test
  - ❑ Defects detection -> Electroluminescence test (EL)
  - ❑ Safety tests -> critical!!!

IEC Reliability Tests and Extended Reliability Tests

Assessment of various influences on PV Modules



- Damp Heat Test (DH) 500 ~ 2,000 h
- Thermal Cycling (TC) for 50 ~ 500 cycles
- Static Mechanical Load for customized load severities
- Impulse Voltage Test
- Hail Impact 25/35/45 mm
- Bypass Diode Thermal Test
- Hot-Spot Endurance Test
- Outdoor Exposure Test
- Salt Mist
- Ammonia Corrosion Test
- Dynamic Mechanical Load
- UV Precondition Test 5 ~ 30 kWh/m² for IEC 61215
- UV Precondition Test 60kWh/m² for IEC 61730
- Thermal Cycling 50 cycles + Humidity Freeze Test 10 cycles

Why choose Supply Chain Quality Assurance Service for certified products?

Testing and inspection covered in Certificate

Test under standard sequence

- **IEC 61215**
  - Crystalline silicon terrestrial photovol
  Design qualification and type approval
- **IEC 61730**
  - Photovoltaic (PV) module safety qua

Factory inspection

- **Documentation check**
  - Verification of applied materials ar
- **Quality management**
  - Documentation of processes
  - Internal quality surveillance programs
- **Production processes**
  - Detail analysis of each step in the production line
  - Internal quality control programs

Standard PV type approval testing for certification are one time testing programs!

Periodical testing and inspections are a must in order to control continuous quality of PV products.

Insufficiencies

- Sample size is small (8 pcs for IEC 61215, 7pcs for IEC 61730).
- Minimum requirement for approval.
- by manufacturer.
- basic reliability requirement, not on
  quality uniformity.

trol of the factory and focus on respective model
ecific order.

nual periodical follow-up inspections only on a
is, not covering for all lines.

process/materials/quality control/personnel are changeful, yearly basis inspection is far from adequate.

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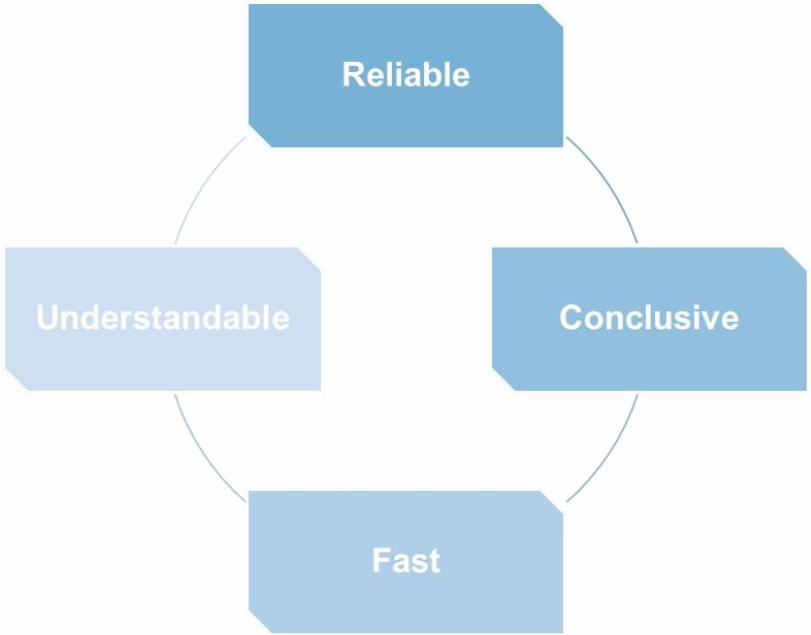
Supply Chain Quality Assurance Services

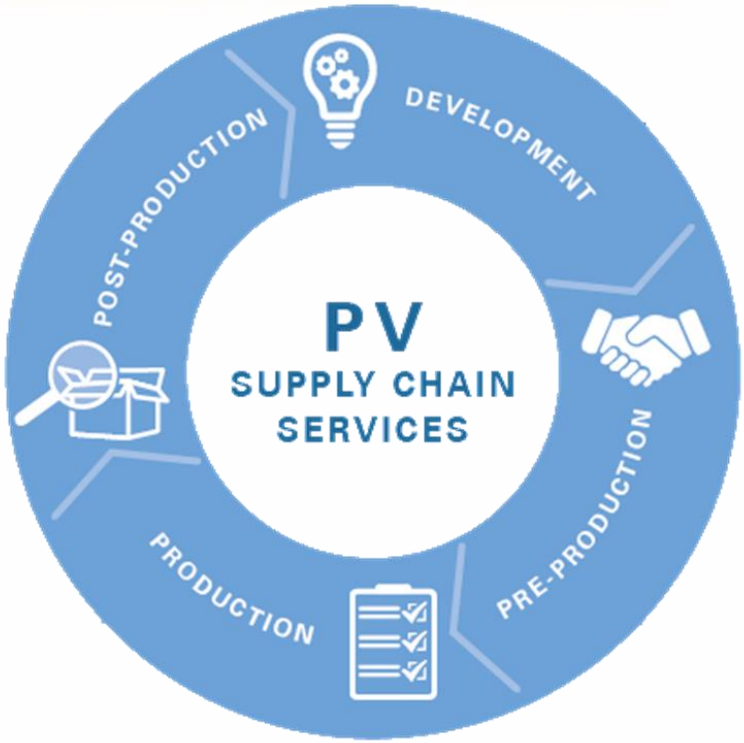
Along each procurement steps

	Sourcing	Production	Post-Production
At Factory	❑ Factory audits	❑ Pre-production inspection ❑ DuPro inspection	❑ Pre-shipment inspection ❑ Loading supervision
In TÜV Rheinland Laboratory		❑ Reference module creation ❑ Reliability Tests	❑ Fast verification test ❑ Final product control test
On Construction site			❑ Post-shipment inspection

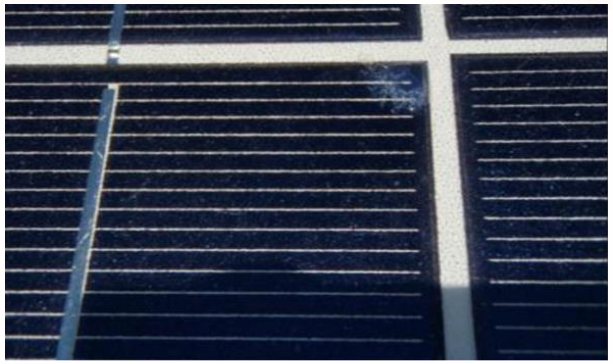
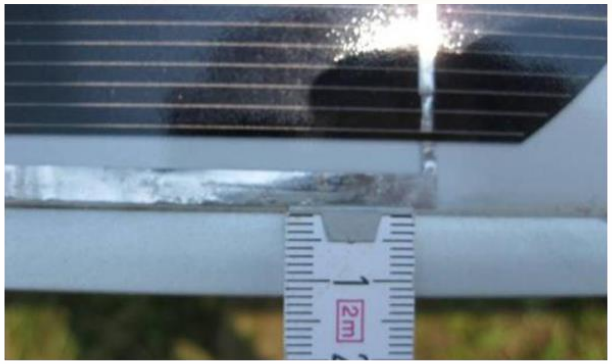
Final Deliverables

Technical reports – Your Benefits

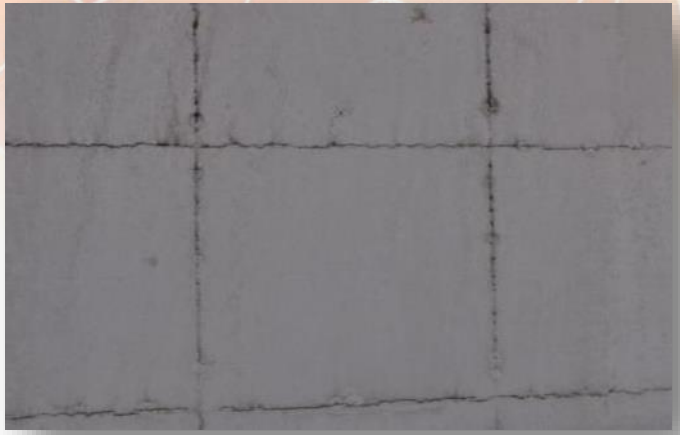


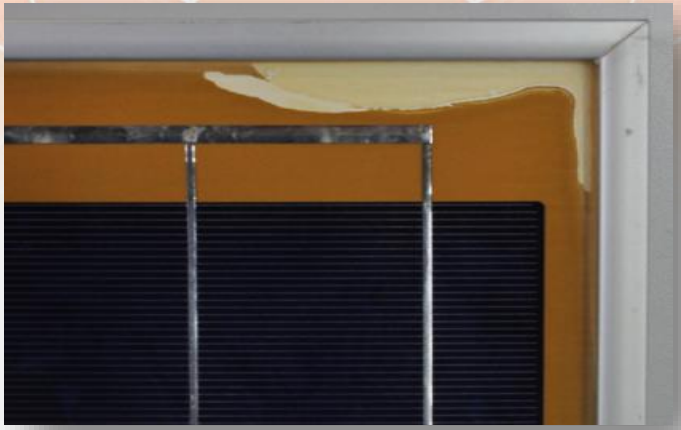


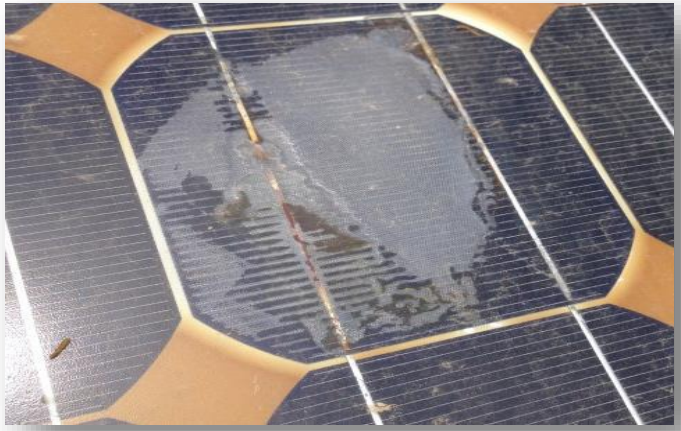
Failure examples

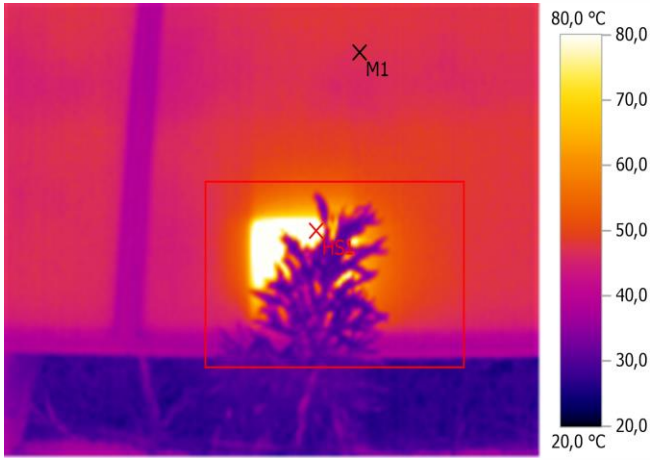









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谢谢！ Thanks for your attention! Gracias por Su Atención

Preguntas?

TÜVRheinland®

Vitor Rodrigues

Regional Field Manager

PV Power Plants & Systems

Solar/ Fucelcell Technology

Spain / SAM

Vitor.rodrigues@es.tuv.com

www.tuv.com

ExpoSolar® Colombia 2019

Julio 11 12 13 Plaza Mayor Medellín Colombia

Medellín - Colombia

www.feriaexposolar.com

Cel: 300 790 8554 / 300 570 7850

info@feriaexposolar.com