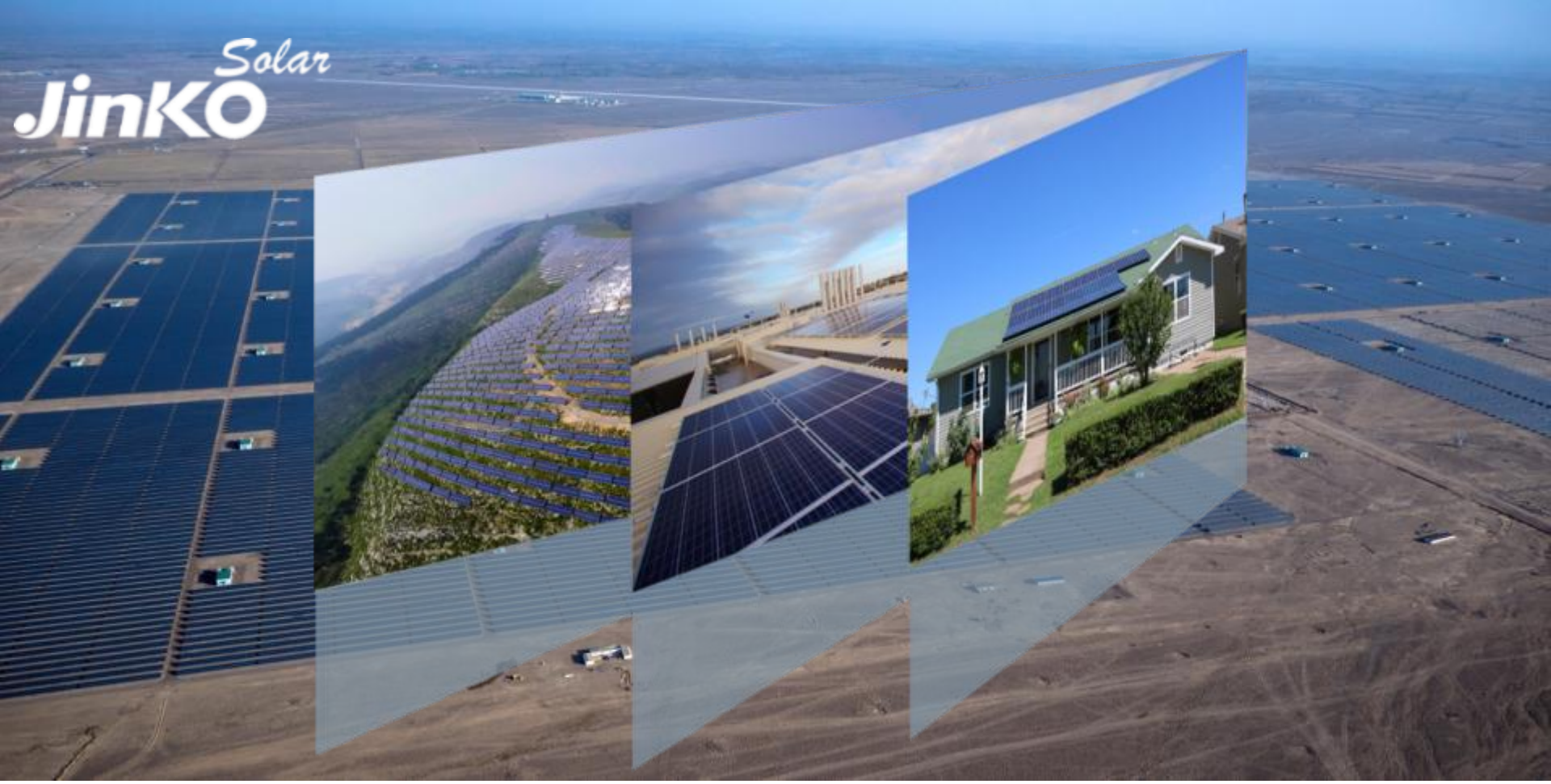
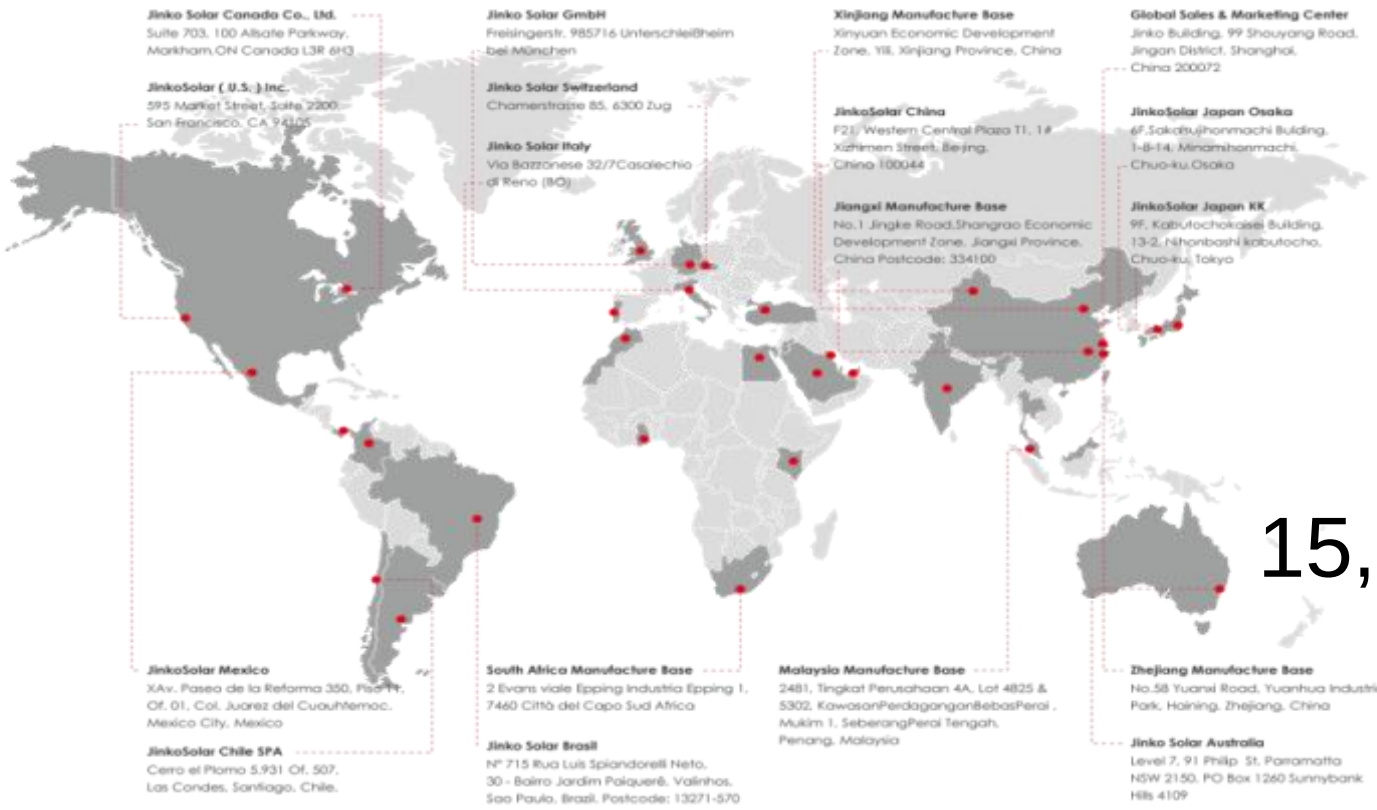



# Cutting Expenditure at the Cost of Investment Returns?
# The Real Value of Durable Materials and Components in Optimizing Solar´s LCOE

**EU PM Dept. 5th June 2018**
**Andrea Viaro, Head of Technical Service & Product Mgmt. Europe**

# Facts and Figures




**8** Global Factories

**31** Subsidiaries

**80+** Countries

**15,000** Employees

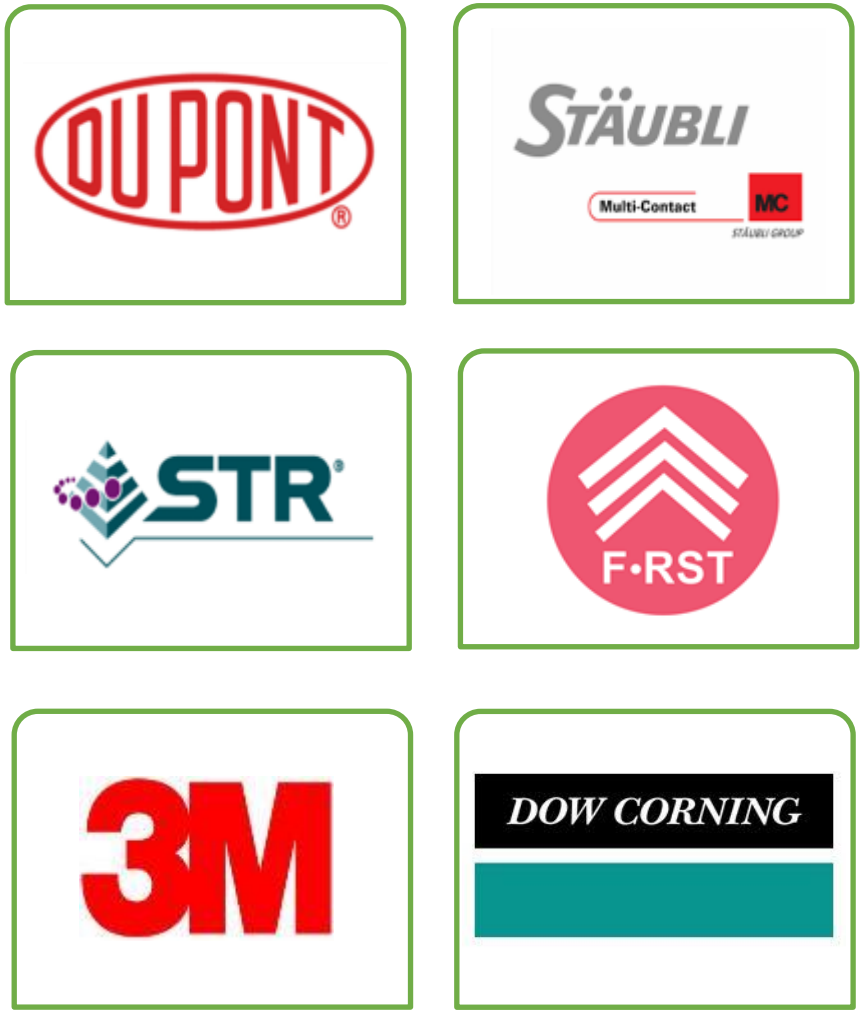
| 9.7 GW | 29 GW |
|---|---|
| Capacity (‘17) | Delivered (Dec’17) |

# R&D leadership

## State Key Laboratory

- **5%** GM expenditures R&D activities
- **>300** full-time technical staff
- **7** in-house cell and module R&D center
- Close cooperation w/h global research Institutes
- Filed **464 patents**

# First-Class Components



# PID-Resistance: The “Eagle” Series

**No Corrective or Preventive Actions for PID**

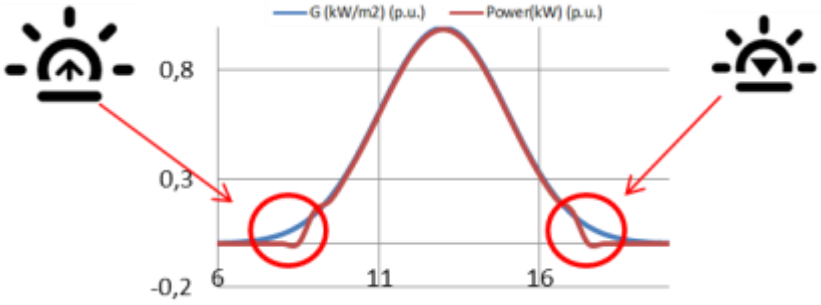
**Typical Installation Topology and Flexibility**

**Maximized Production**

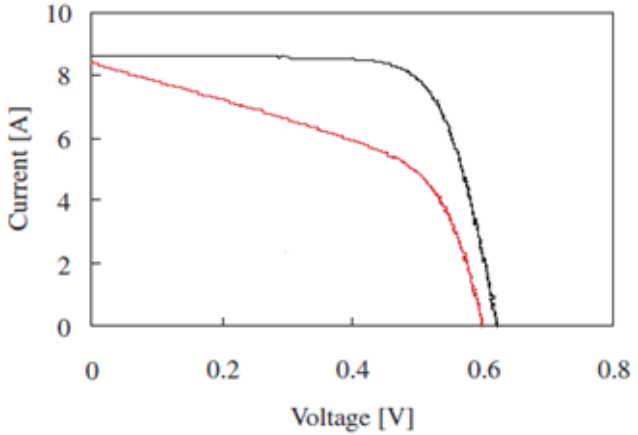
**First PID-resistant Module**
**(IEC62804 Standard)**
**85℃/85% RH, 192 hrs.**

# PID'S MAIN FACTORS

- **Climate weather conditions**: temperature, humidity
- **System topology:** module position, system voltage
- **Module**: encapsulant and design/structure (frame, isolation)
- **Cells**: Anti-Reflecting Coating




Inverter Wake Up and Drop Off (Voc)

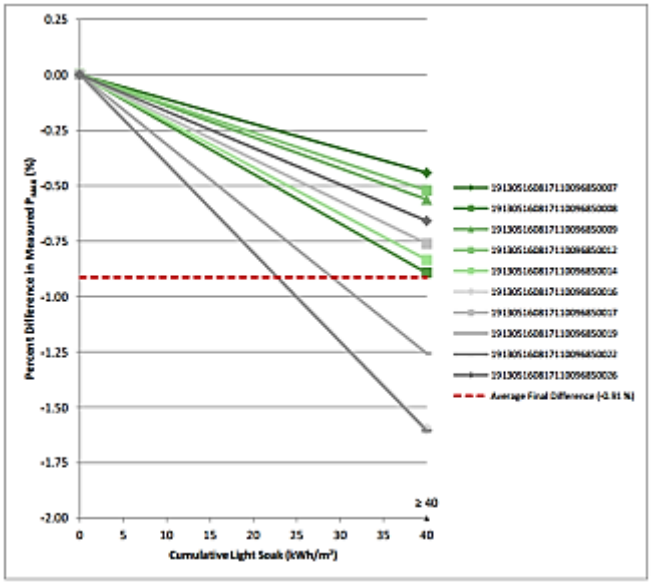


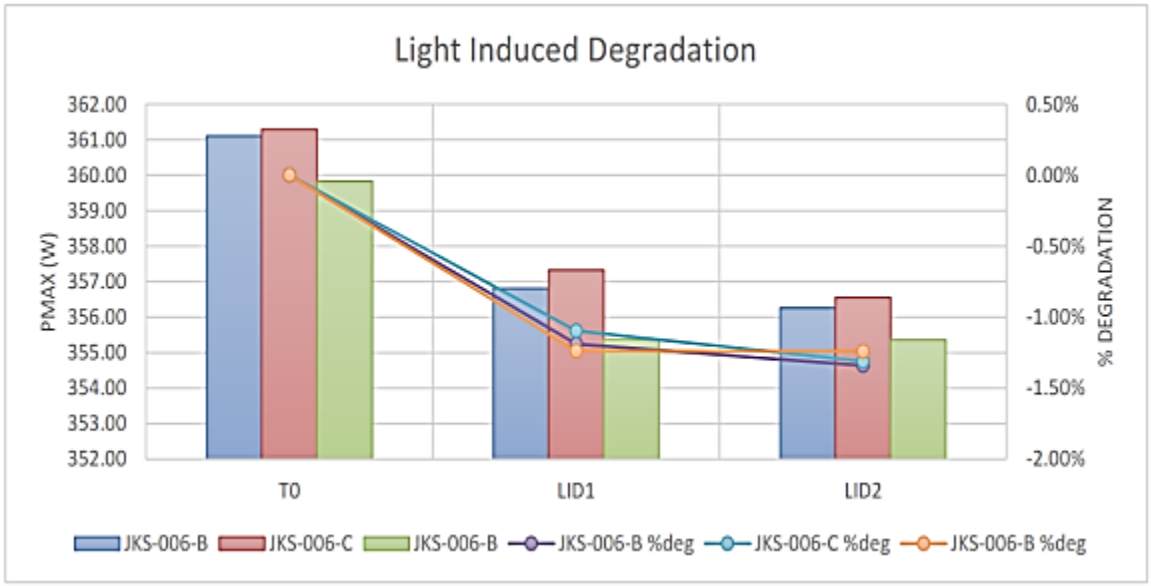

Effects on IV-Curve : Rsh, FF, Vmpp, Impp, Voc

# Reliable Performance: LID control

DNV·GL

RETC California RENEWABLE ENERGY TEST CENTER CALIFORNIA




**Poly modules**
**JKM320PP-V tested**
**Results: -0.9% (average)**

**Mono PERC modules**
JKM355M-72-V, JKM285M-60
**Results: -1.3% (Average)**

*Reference : DNV-GL & RETC California*

# Connector “Compatibility”



- Connectors for photovoltaic systems shall comply with IEC 62548 TS

- IEC 62548 TS: Design requirements for photovoltaic (PV) arrays
  “…connectors mated together in a PV system shall be of the same type from the same manufacturer”

- PV Module Installation Manual:
  Applicable local and national Electrical Codes shall be fulfilled for module wiring

- Potential PV Module Warranty waiver

# Micro-Crack Control Along the Value Chain

**Silicon**

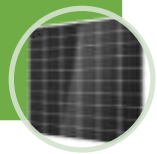
- Control of silicon ingot brittleness
- Wafer EL tests: crack rate below 1/1000

**Cell**

- Cell EL tests: crack rate below 2/1000

**Module**

- “Zero–Crack” module prod. process yield >than 99.5%
- Online automated vision inspection



**Package**

- Integrated turn-over packaging method

**Transportation**

- Monitoring of mechanical shock during transportation

**Installation**

- Best-practice installation guidelines
- Avoid cell cracks caused by improper handling

**Maintenance**

- Portable EL tester for onsite monitoring of cracks occurrence due to O&M activities

# “ZERO Micro-crack” Programme

| Success rate | 2016 | 2017 |
|---|---|---|
| Pre-shipment | 99.65% | 99.83% |
| Post-shipment | 99.2% | 99.97% |

Pre-shipment

Post-shipment

- EVA thickness and density increase/optimization
- Cell Soldering optimization & automation
- Automatic turn-over packing machine

# Long-Term Performance: Accelerated Aging

DNV·GL

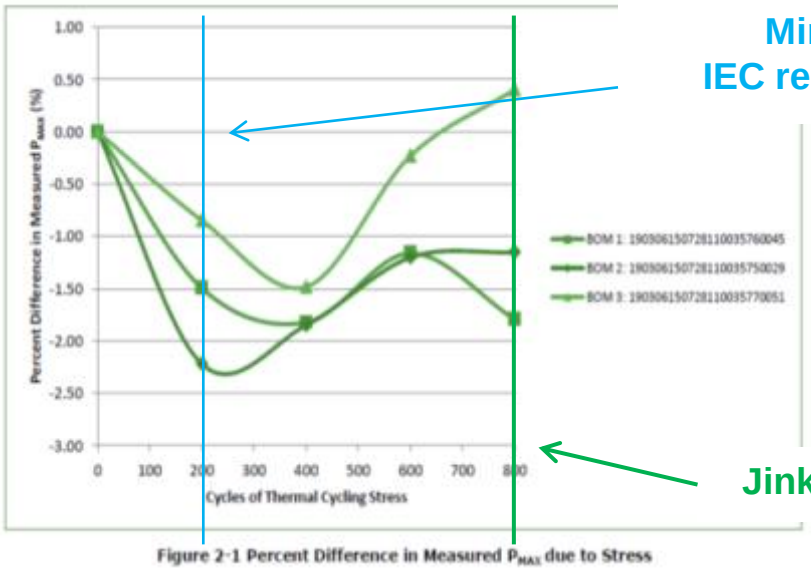



Figure 2-1 Percent Difference in Measured $P_{MAX}$ due to Stress

**Minimum IEC requirement**

**Jinko Solar**

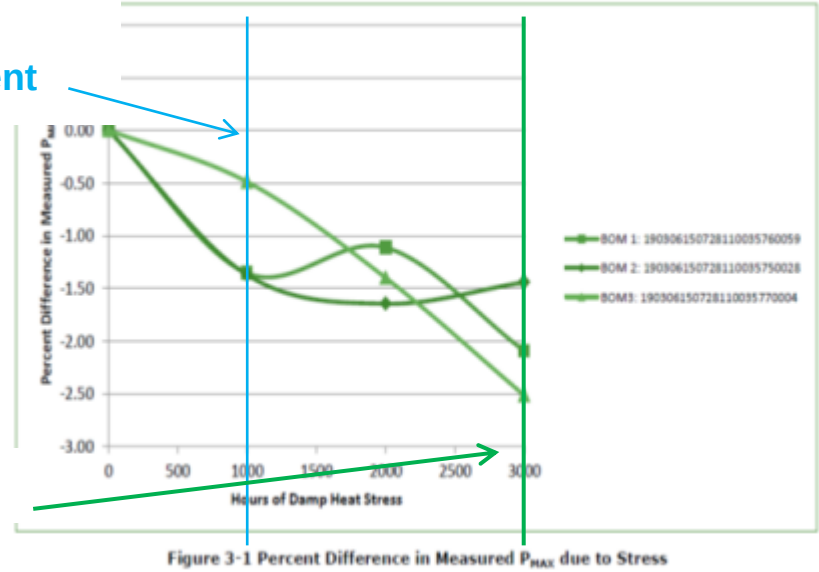



Figure 3-1 Percent Difference in Measured $P_{MAX}$ due to Stress

**Thermal Cycle 800**
**4x MORE SEVERE THAN STANDARD**
**El. Connections Stress Test**
**Results: -0.85% (average)**

**Damp Heat 3000**
**3x** MORE SEVERE THAN STANDARD
Laminate Stress Test
**Results: -2.01% (average)**

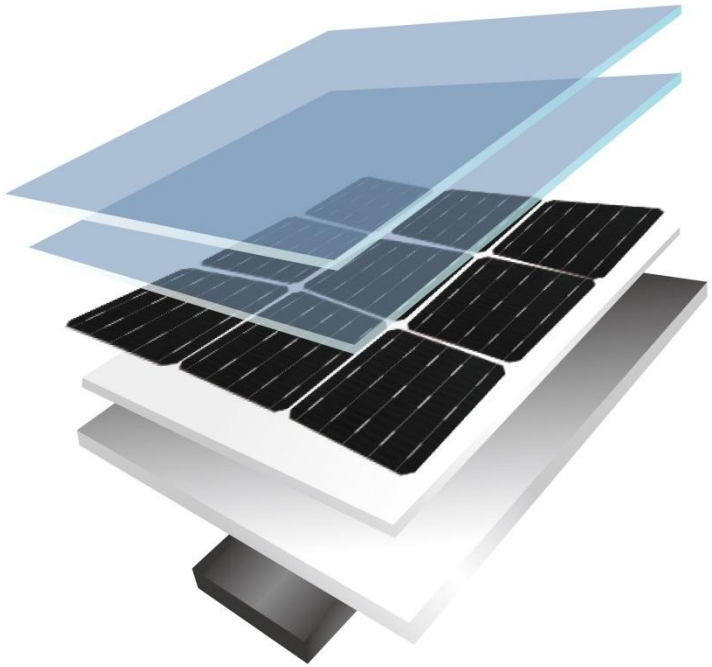
*Reference : DNV-GL*

# Laminate Reliability: UV-light Resistance

- First Chinese PV Manufacturer to Receive the IEC61345 Certification from TÜV Rheinland
- Ultraviolet-B light resistance ("UVB", 320~280 nm λ)
- 10 x testing conditions, compared to IEC61215 (15 kWh/m$^2$ UV irr. with 5 kWh/m$^2$ UVB)
- >137.8 kWh/m$^2$ UVA+UVB (400~280 nm)

# Improved UV-light Resistance

| | Yellowing Index (UV) | UV-light Resistance (T%) | Water Vapor Transmission Rate (g/m2·d) |
|---|---|---|---|
| **TPT + Transp. EVA** | 6.00 | 0.012 | 2.60 |
| **TPE + White EVA** | **0.88** | **0.010** | **2.01** |
| Test purpose | Simulate 25y aging in harsh environment (432 KW.h/m2 UV irradiance) | Inner PET layer protection against UV light | Protection against moisture ingress into the laminate |
| Results | 10 times lower UV index → lower material aging | PET core exposed to only 0.04kW.h/$m^2$ UV in 25y | 20% better WVTR |



**Improved TPE + White EVA Solution**

# Third-Party Testing: Accelerated Aging

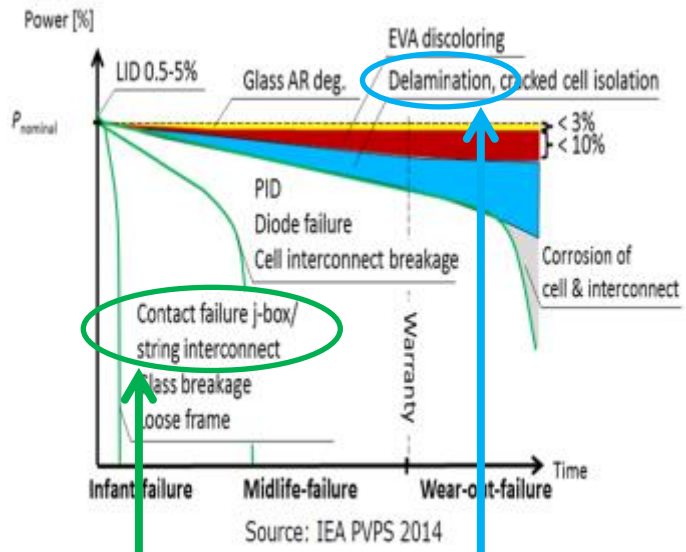



Figure 2-1 Aging mechanisms leading to PV module degradation

**TOP PERFORMER in 2018**

**Test Protocol:**

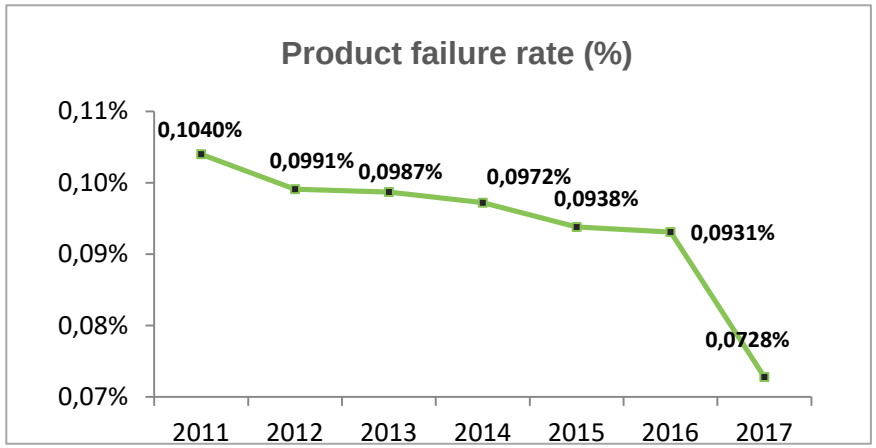
**DH1000**
**TC600**
**UF30**
**UV90**
**DML1000**
**PID192**

DNV·GL

| | TOP PERFORMER 2018 | TOP PERFORMER 2017 | TOP PERFORMER 2016 | TOP PERFORMER 2014 |
|---|---|---|---|---|
| Jinko Solar | ✓ | ✓ | ✓ | ✓ |
| Trina Solar | ✓ | ✓ | ✓ | ✓ |
| Yingli Solar | ✓ | ✓ | ✓ | ✓ |
| Astronergy Solar | ✓ | ✓ | | ✓ |
| Hanwha Q CELLS Co., Ltd | ✓ | ✓ | ✓ | |
| JA Solar Holdings | ✓ | | ✓ | ✓ |
| REC Solar | ✓ | ✓ | ✓ | |
| BYD Co, Ltd | ✓ | ✓ | | |
| Flex Ltd | ✓ | ✓ | | |
| GCL Solar Energy, Inc | ✓ | ✓ | | |
| LONGi Solar Technology Co, Ltd | ✓ | ✓ | | |
| Neo Solar Power Corporation (NSP) | ✓ | ✓ | | |
| Phono Solar Technology Co, Ltd | ✓ | | ✓ | |
| Solaria Corporation | ✓ | ✓ | | |
| SunPower Corporation | ✓ | ✓ | | |
| SunSpark Technology, Inc | ✓ | ✓ | | |
| Suntech Power | ✓ | | | ✓ |
| Adani (Mundra Solar PV Ltd) | ✓ | | | |
| First Solar, Inc | ✓ | | | |
| HT-SAAE | ✓ | | | |
| LG Electronics, Inc | ✓ | | | |
| Panasonic | ✓ | | | |


Thank you!

# Service – Industry Benchmark





**Fast response:**
Local Branches with CS Personnel

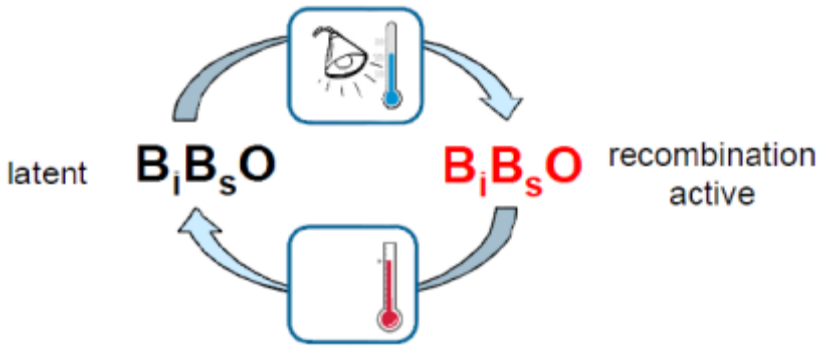
**Professional Service:**
Experienced engineers for both Pre/After-Sales Support

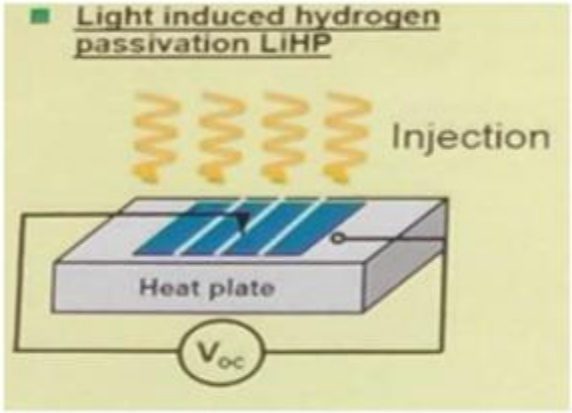
**Continuous Improvement:**
Thorough troubleshooting and CAPA implementation

**Customer-Oriented:**
Tailored Solutions and Consistent follow-up

# Light Induced Degradation (LID) Solution

- Illumination of mono cz. P-type solar cells → Eff. reduction up to **5%** abs
- Main cause: recombination of active **Boron–Oxygen** complexes (B-O), especially in highly Boron-doped & Oxygen-rich silicon

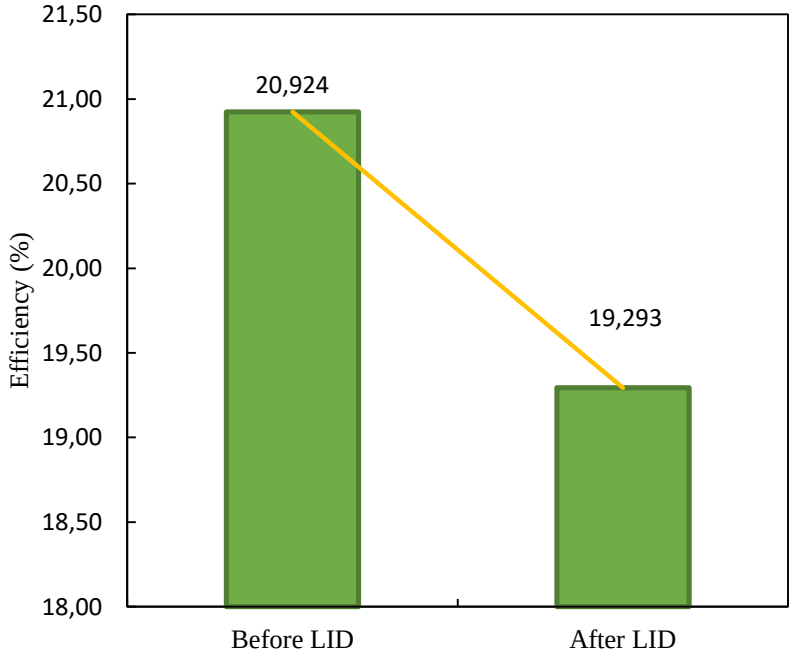


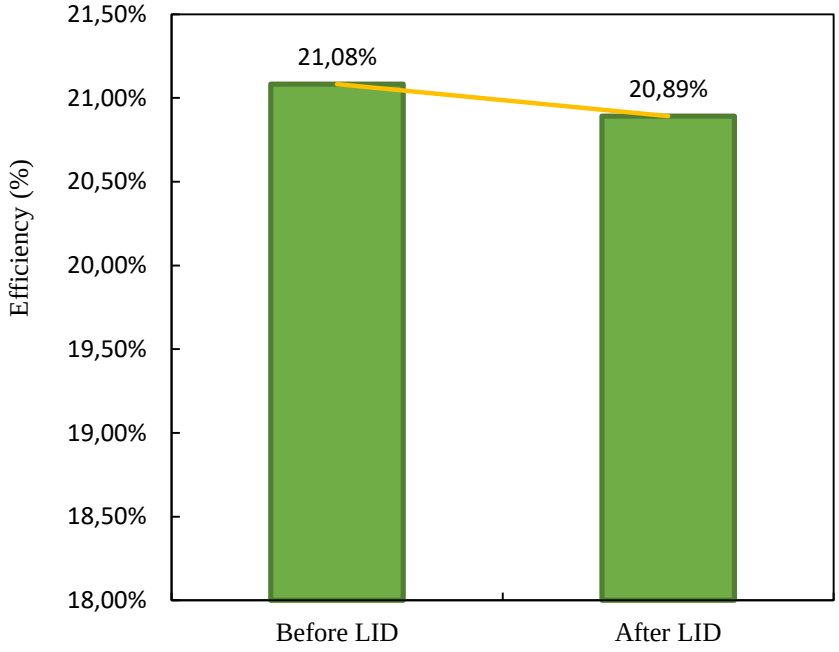

- **Light-induced Hydrogen Passivation** (LiHP) can dramatically reduce LID, i.e. regeneration process
- Key parameters to deactivate Boron–Oxygen complex (Passivation): Temperature, carrier injection, Hydrogen diffusion

# LID Regeneration Effect

## Without LiHP




## With LiHP




Testing condition
Irr 900-1000 W/m $^2$
Cell Temp. 50-60℃
Light Soaking 5 hours