ENERGY

Quality of Components: Due Diligence and the Role of the Planning Phase

3 May 2018, Brussels

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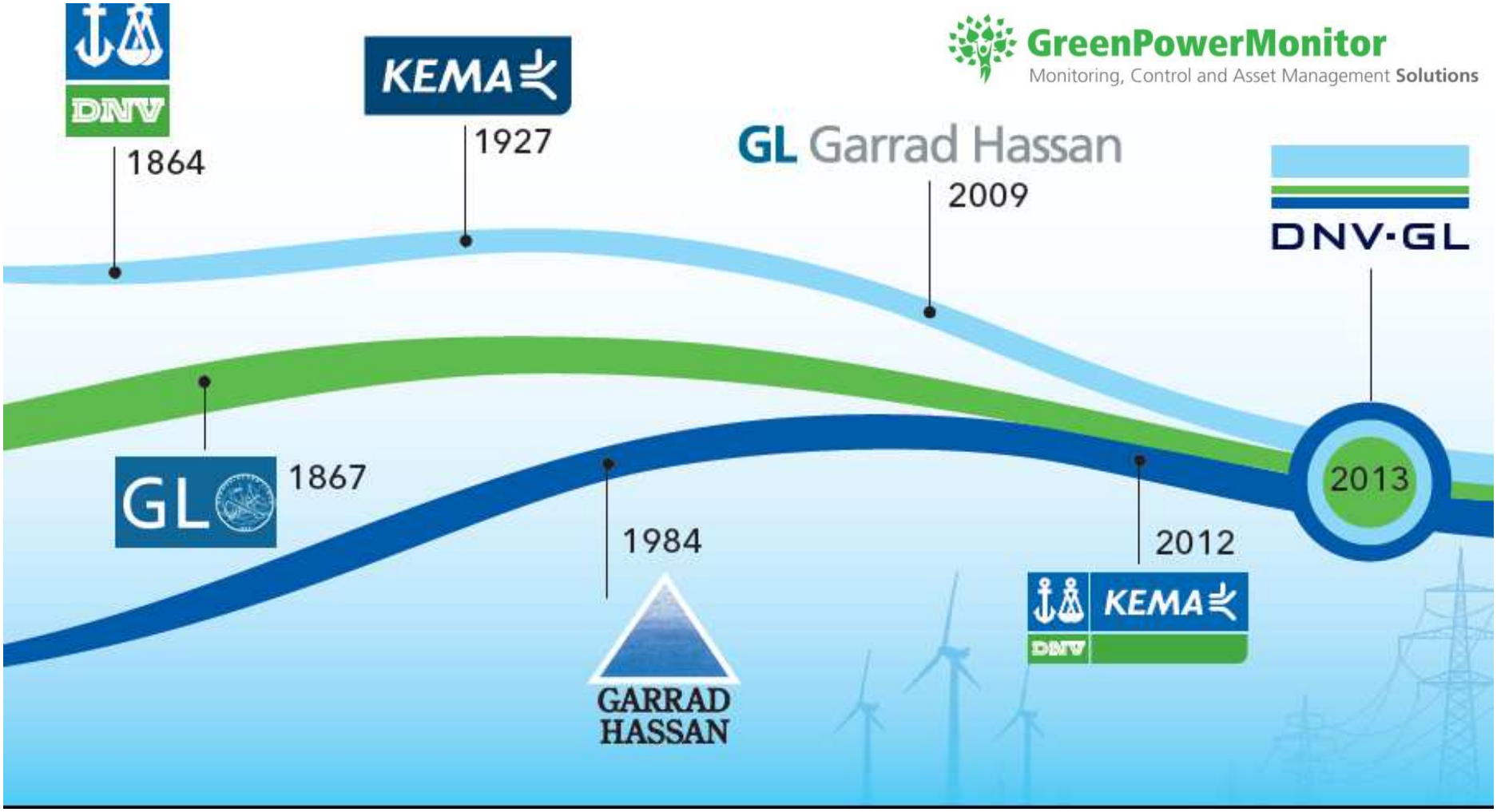
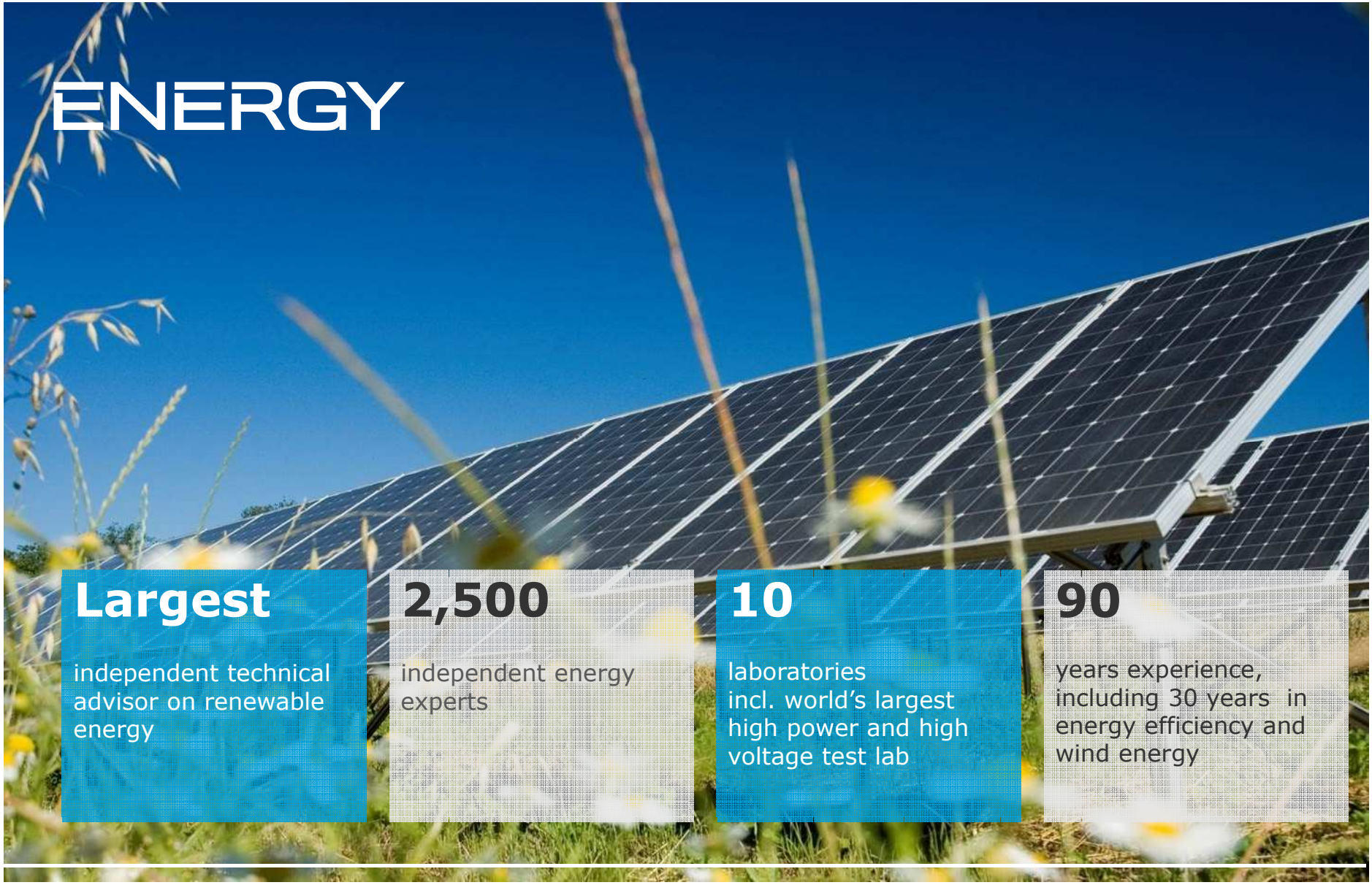
03 May 2018

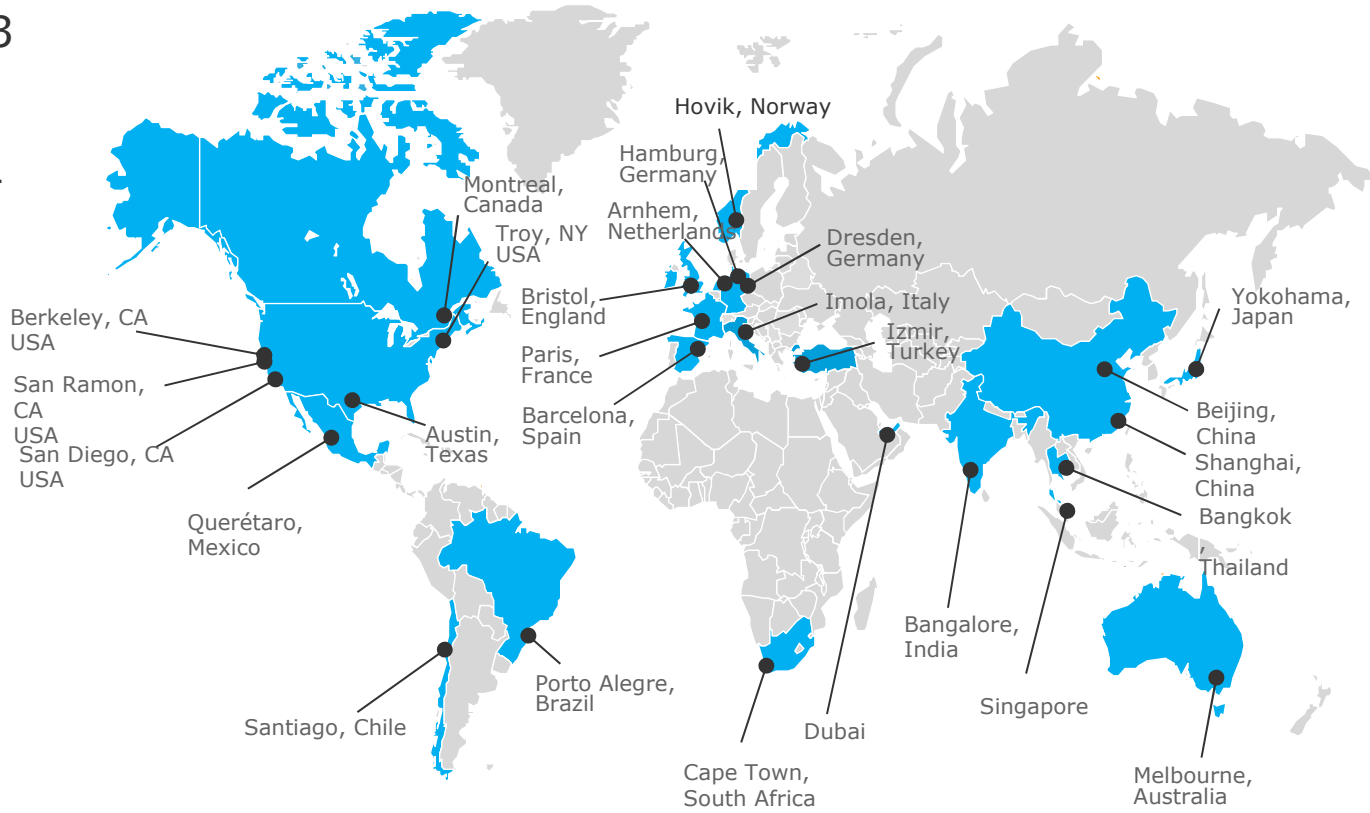
DNV GL - More than 150 years of Experience in the Industry



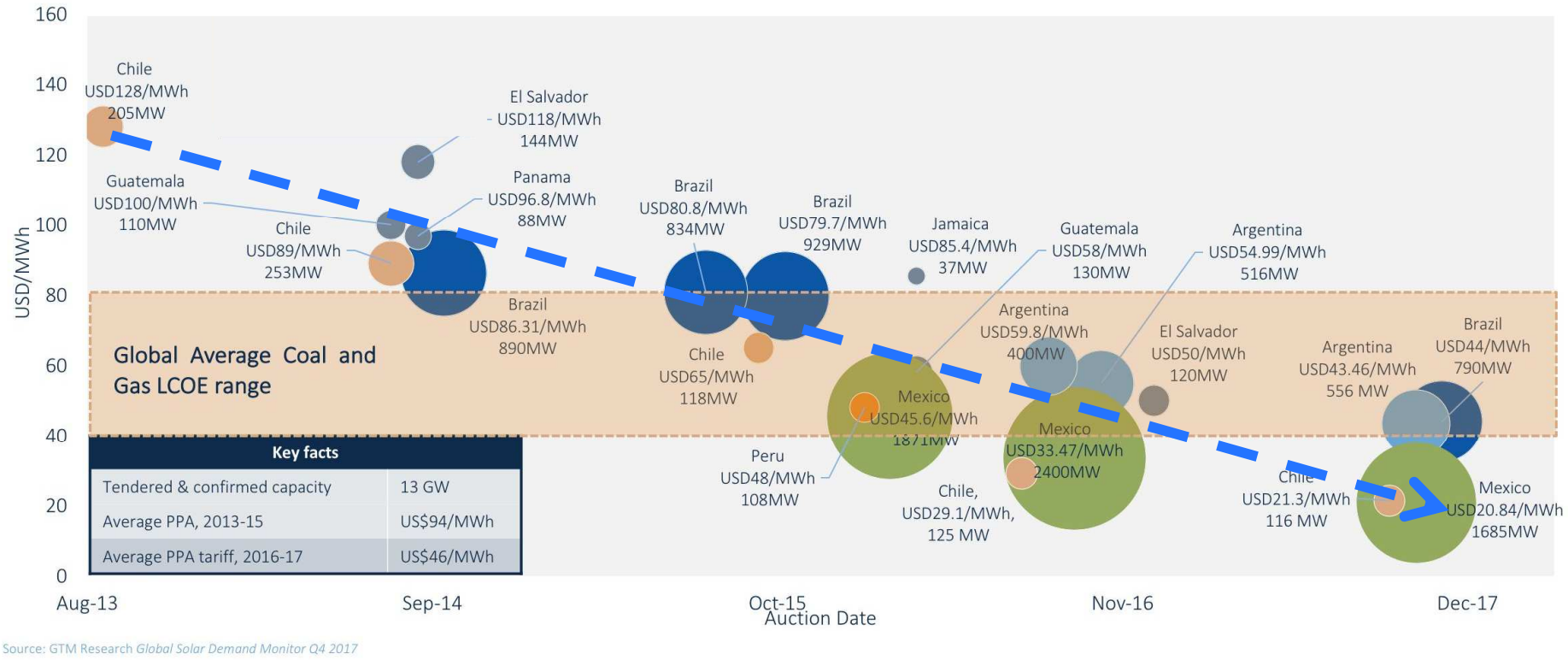

ENERGY
Largest
independent technical advisor on renewable energy
2,500
independent energy experts
10
laboratories incl. world's largest high power and high voltage test lab
90
years experience, including 30 years in energy efficiency and wind energy

DNV GL has a global Solar presence

- Solar **advisory** services since 1993
- Full **range** of advisory services—helping our customers to **manage risk**
- Global team of **solar experts**
- **Leading** solar financiers, developers and component manufacturers are customers



Global Market Context

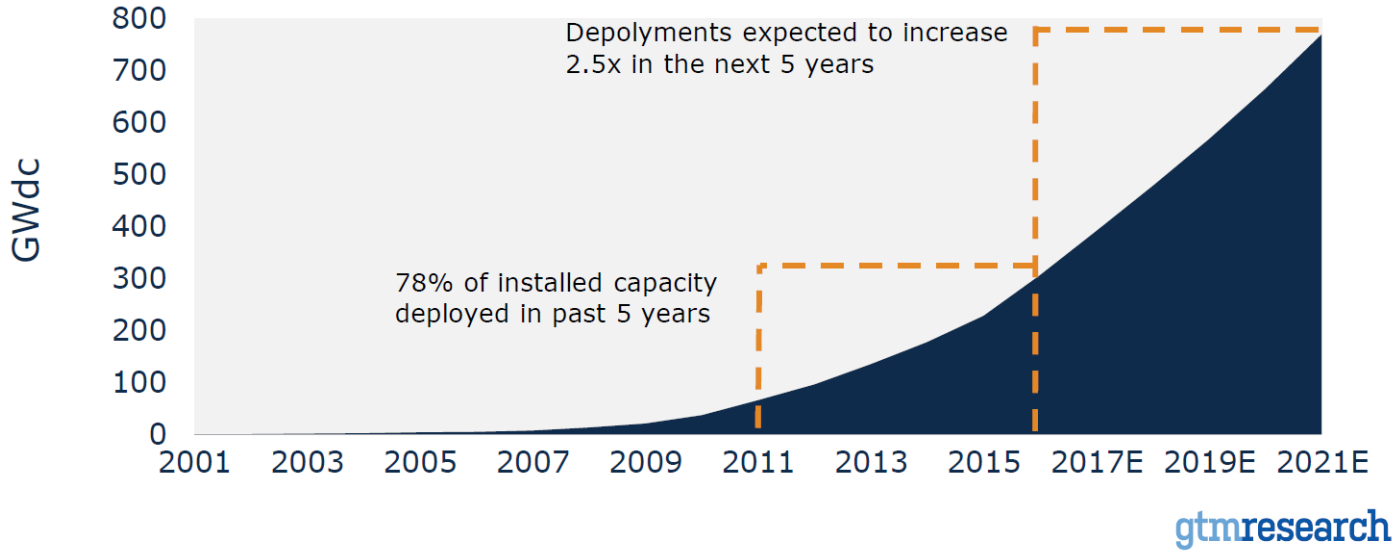


Source: GTM Research *Global Solar Demand Monitor Q4 2017*

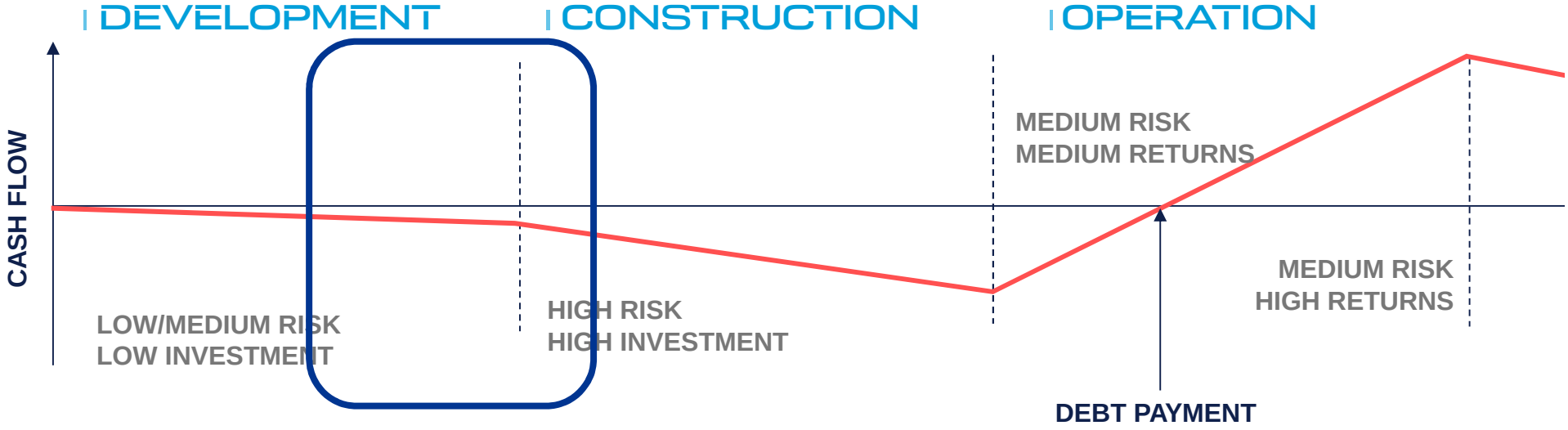
SIGNIFICANT COST REDUCTION GLOBALLY

Global Market Context

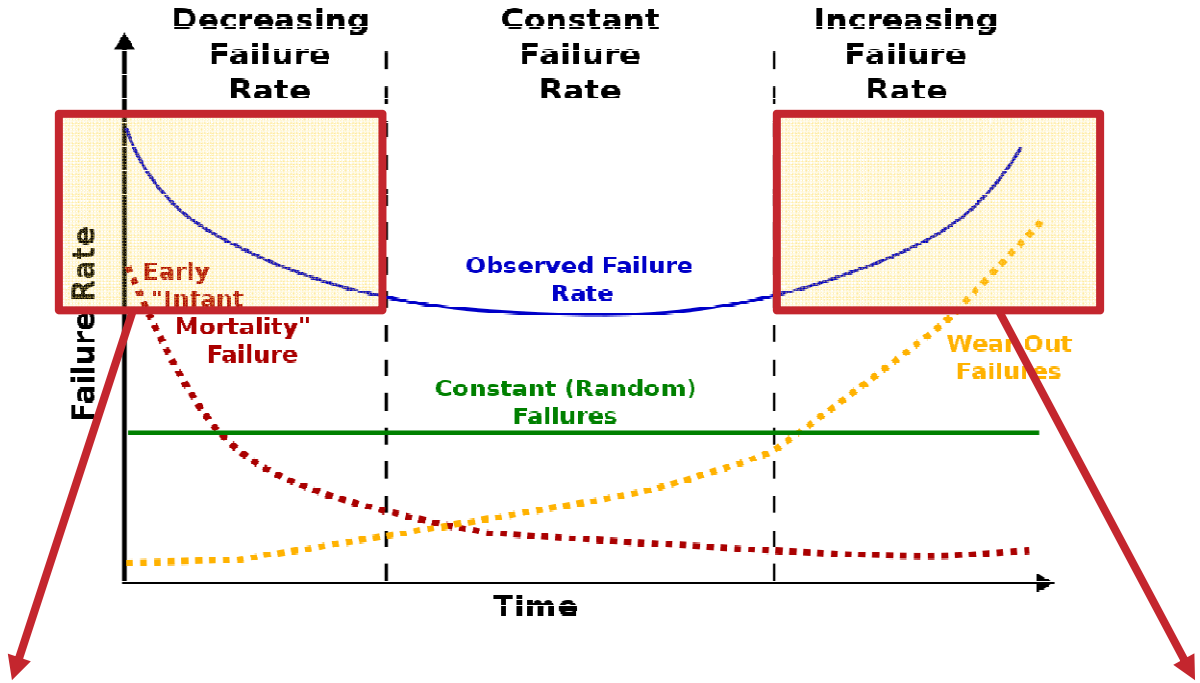
- > 35% Growth in 2018 expected in Europe
- Increasing demand from Spain and the Netherlands, supporting the development of large-scale Projects
- Sustainable growth not dirven by FIT
- Non subsidised Projects to come online



Project Risks at different Development Stages



Procurement Best Practices Designed to Reduce Project Risks



Statistical Batch Testing

= Serial Defect Screening

= IEC-compliance tests

= Infant-mortality testing

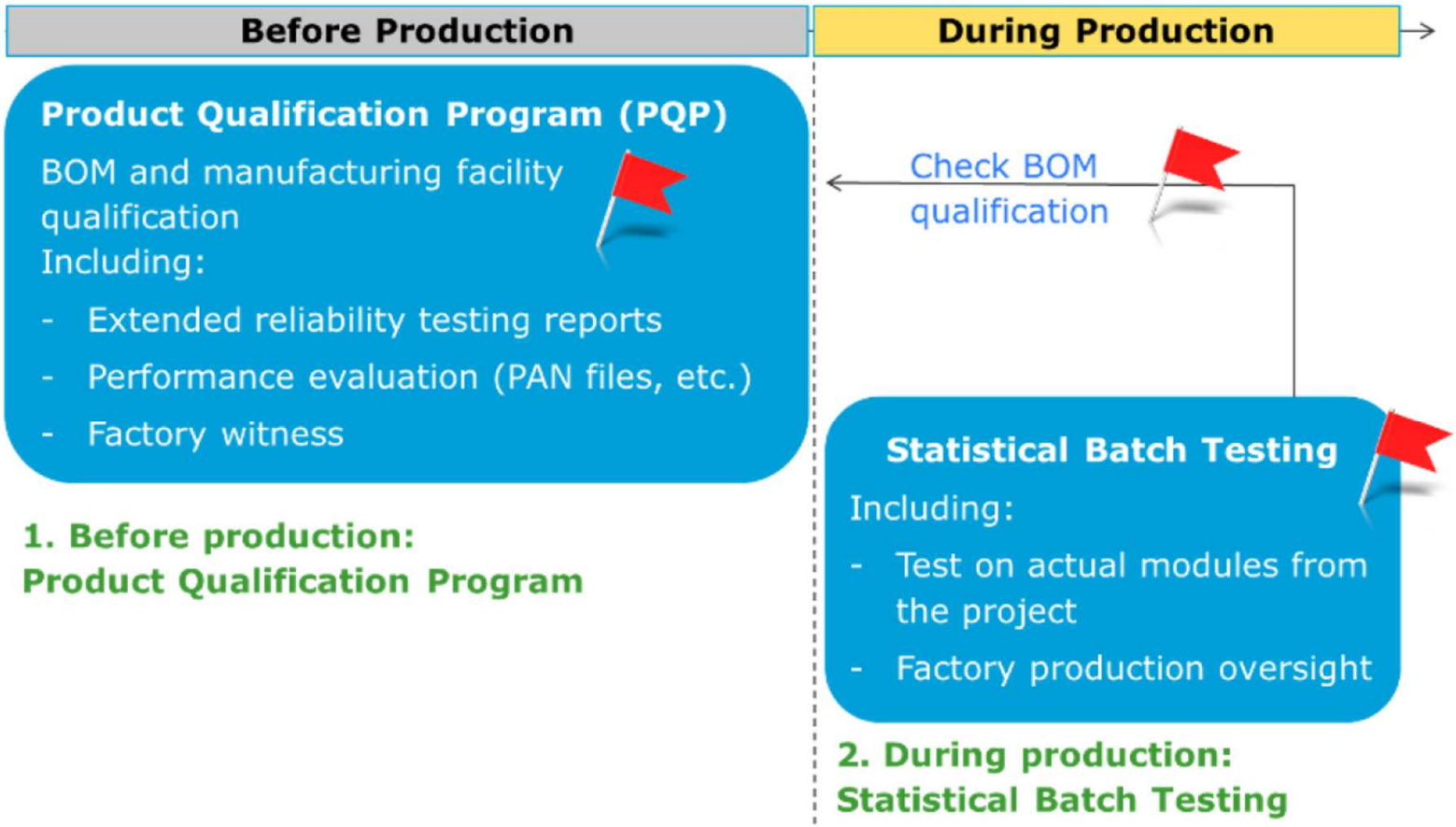
Product Qualification Program

= Extended reliability testing

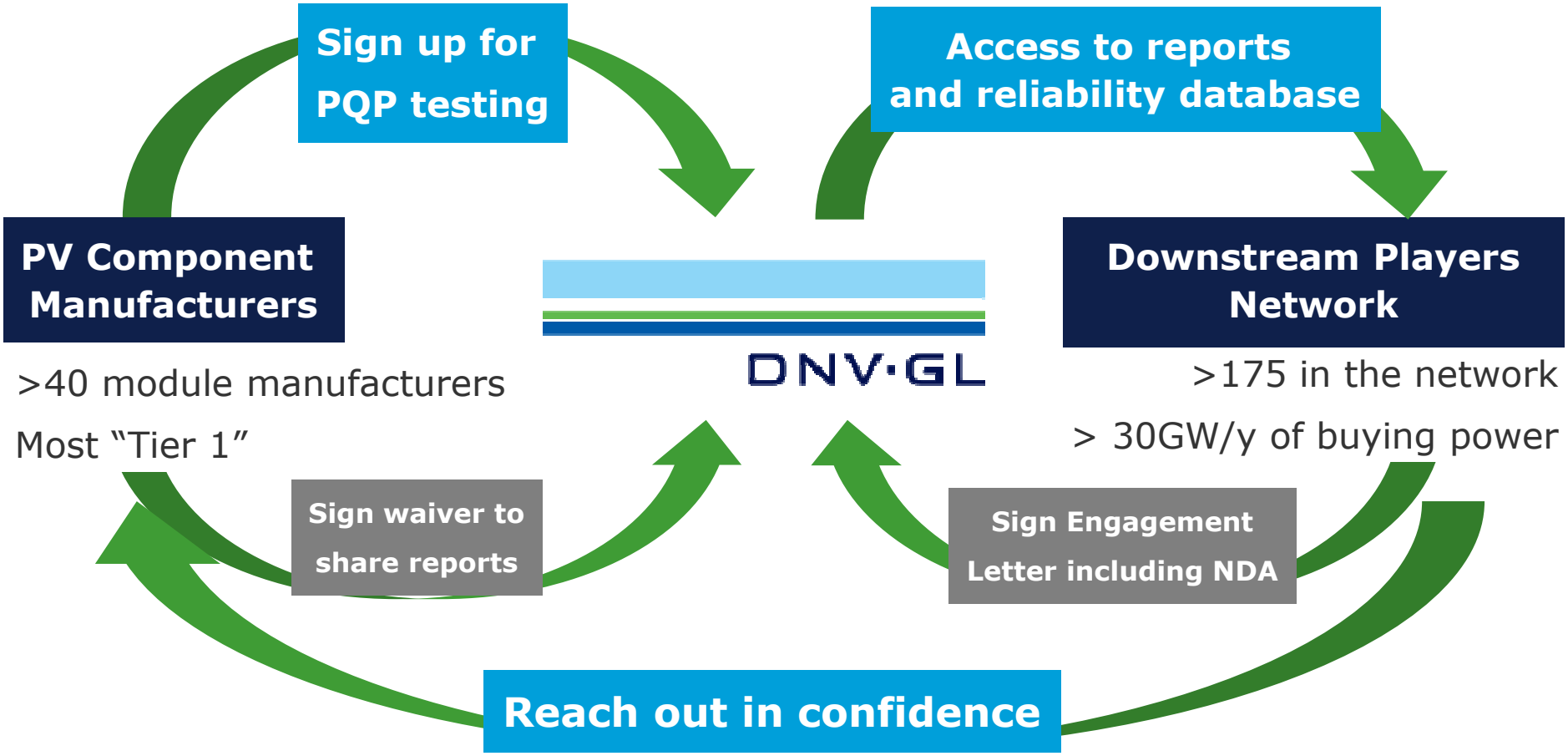
= 2-4 times IEC durations

= wear-out mechanisms testing

Procurement Best Practices Designed to Reduce Project Risks



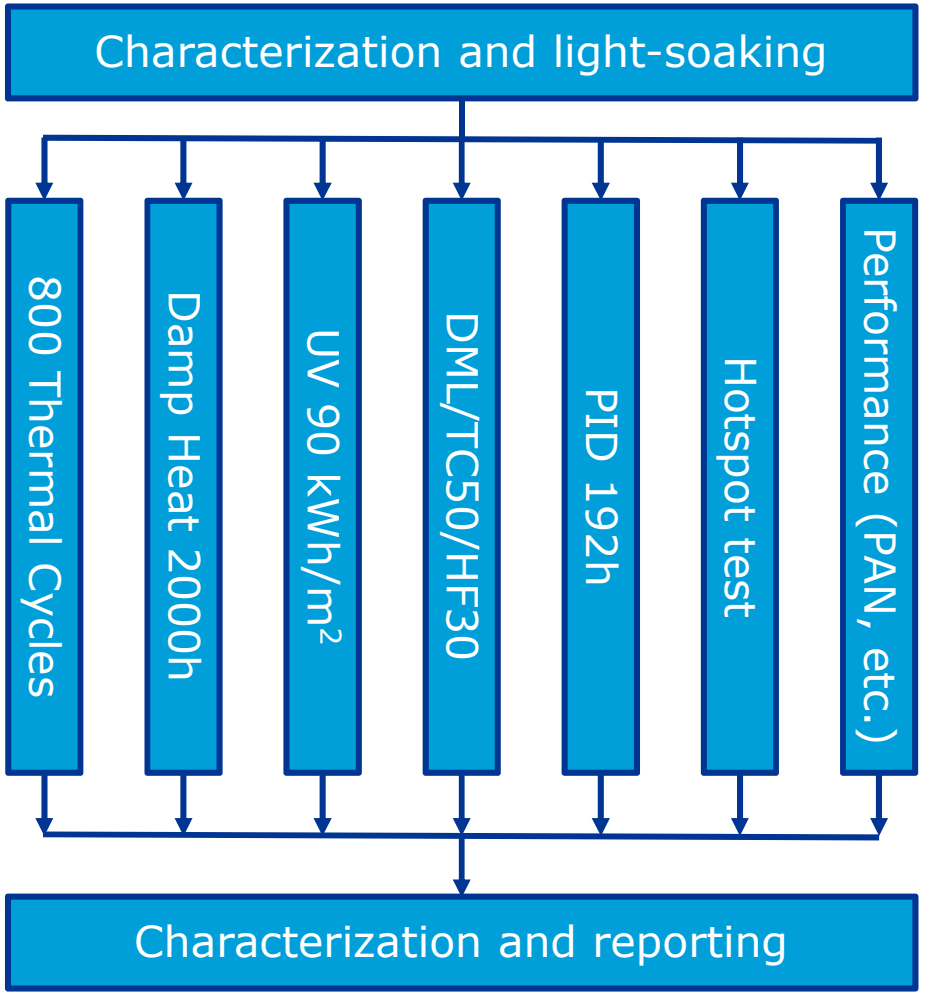
DNV GL PQP is building trust



- **Several hundred reports** available to DNV GL Downstream Partners
- **World's largest reliability database** of commercial PV products

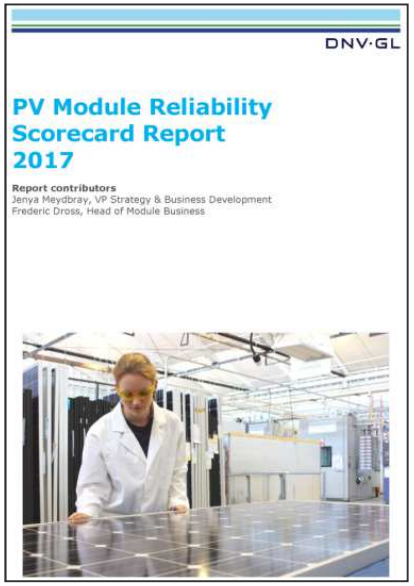
DNV GL PV module PQP approach

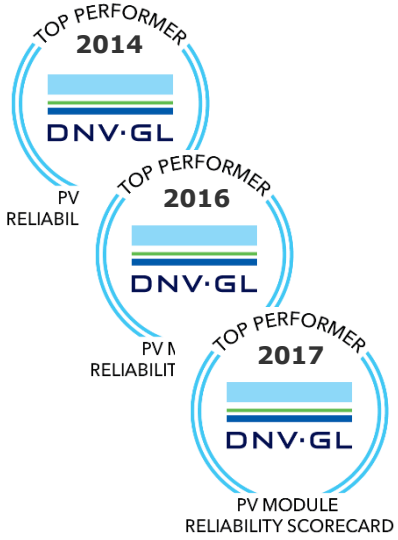
- **Tough** testing scope (x2 – x4 IEC)
- **Designed by and for** the community (including 175+ DNV GL Downstream Partners)
- **Most Tier 1 manufacturers**:
  - 70-75% of the Tier 1 list
  - 9 out of the 10 largest manufacturers
- **Adapted** to testing of most common failure modes:
  - ✓ Bifacial
  - ✓ PERC
  - ✓ High-Density Modules (shingle)
  - ✓ Glass-glass
  - ✓ Thin-film
  - ✓ …



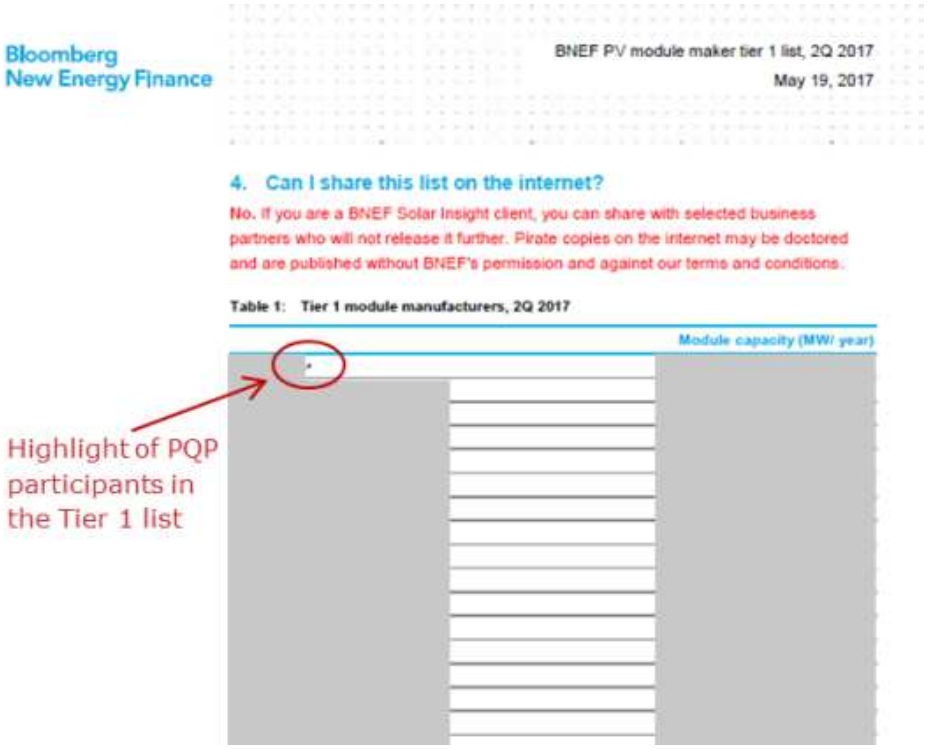
Who are the PQP participants?

- **DNV GL PV Module Reliability Scorecard**
  - Every year, thousands of downloads
  - Top Performers allowed to use a DNV GL mark on their datasheets





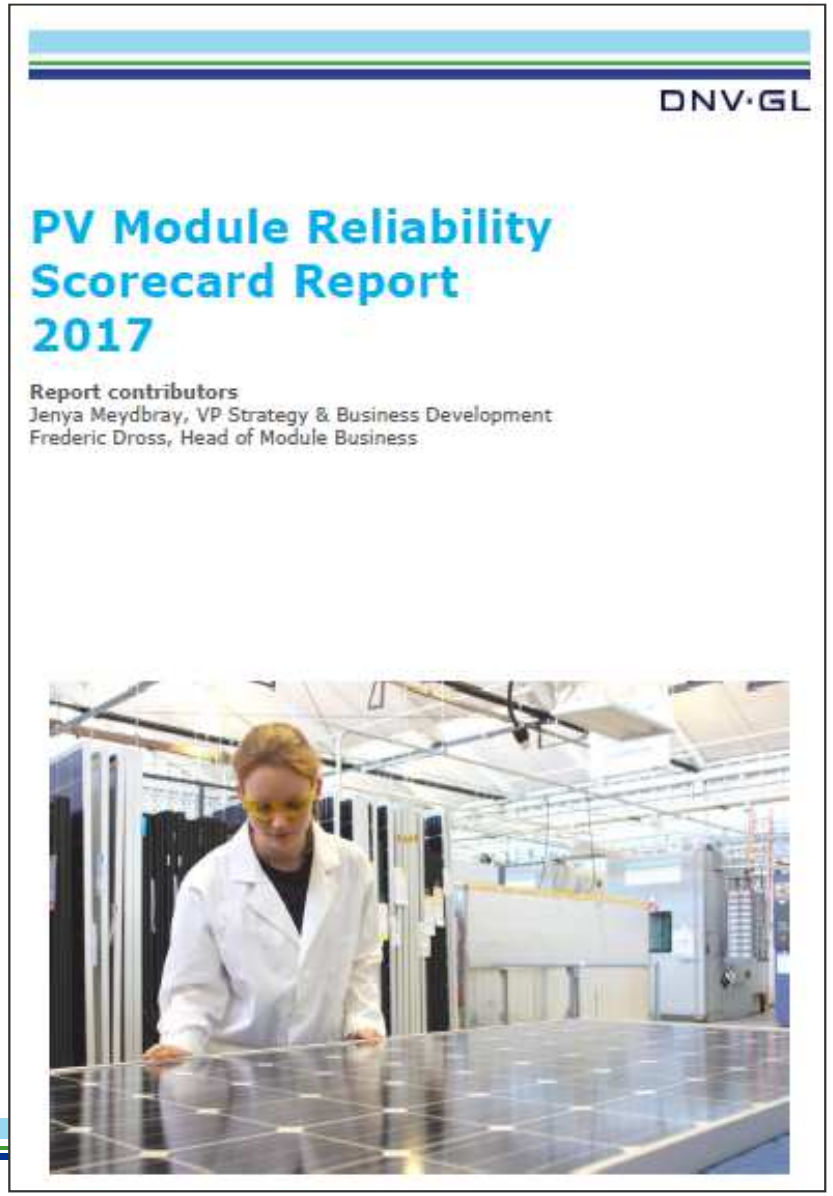
- **Bloomberg (BNEF) Tier 1 list**
  - The manufacturer list the most widely used around the world for procurement decisions



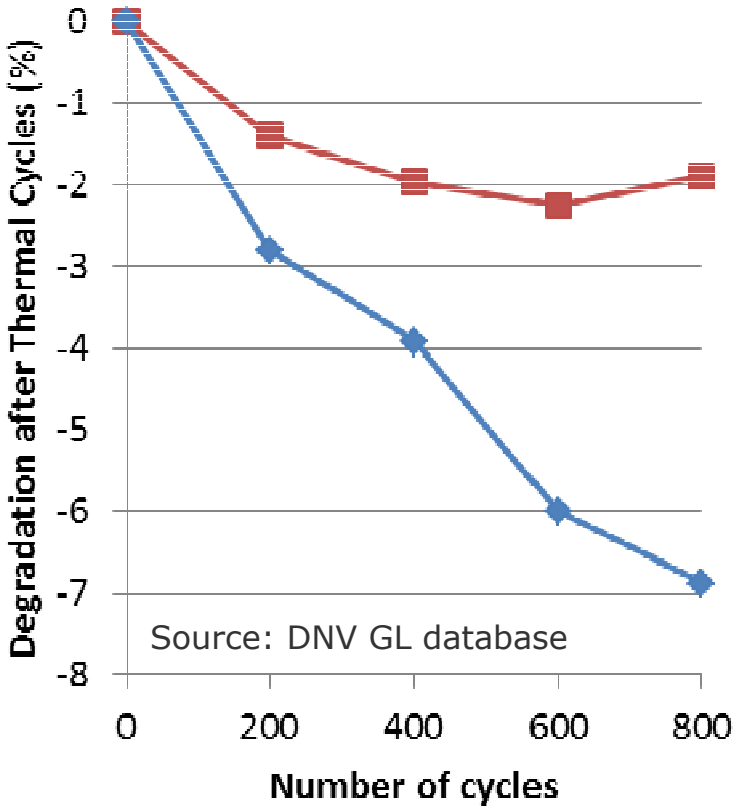
2017 DNV GL PV Module Reliability Scorecard

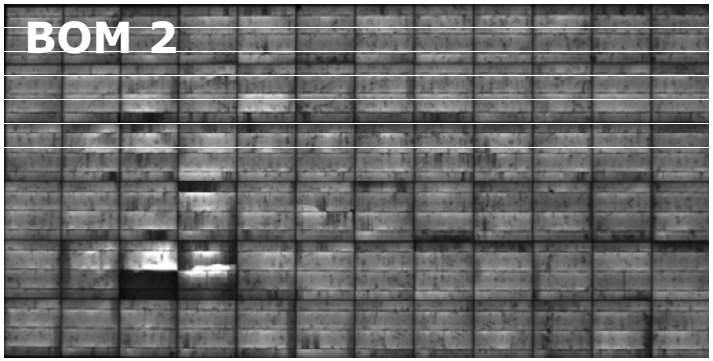
- All results are from the **DNV GL PQP**
- **250+** data points
- **50+** different BOMs
- **10** different countries

- **Scorecard 2018 coming up Q2 2018**



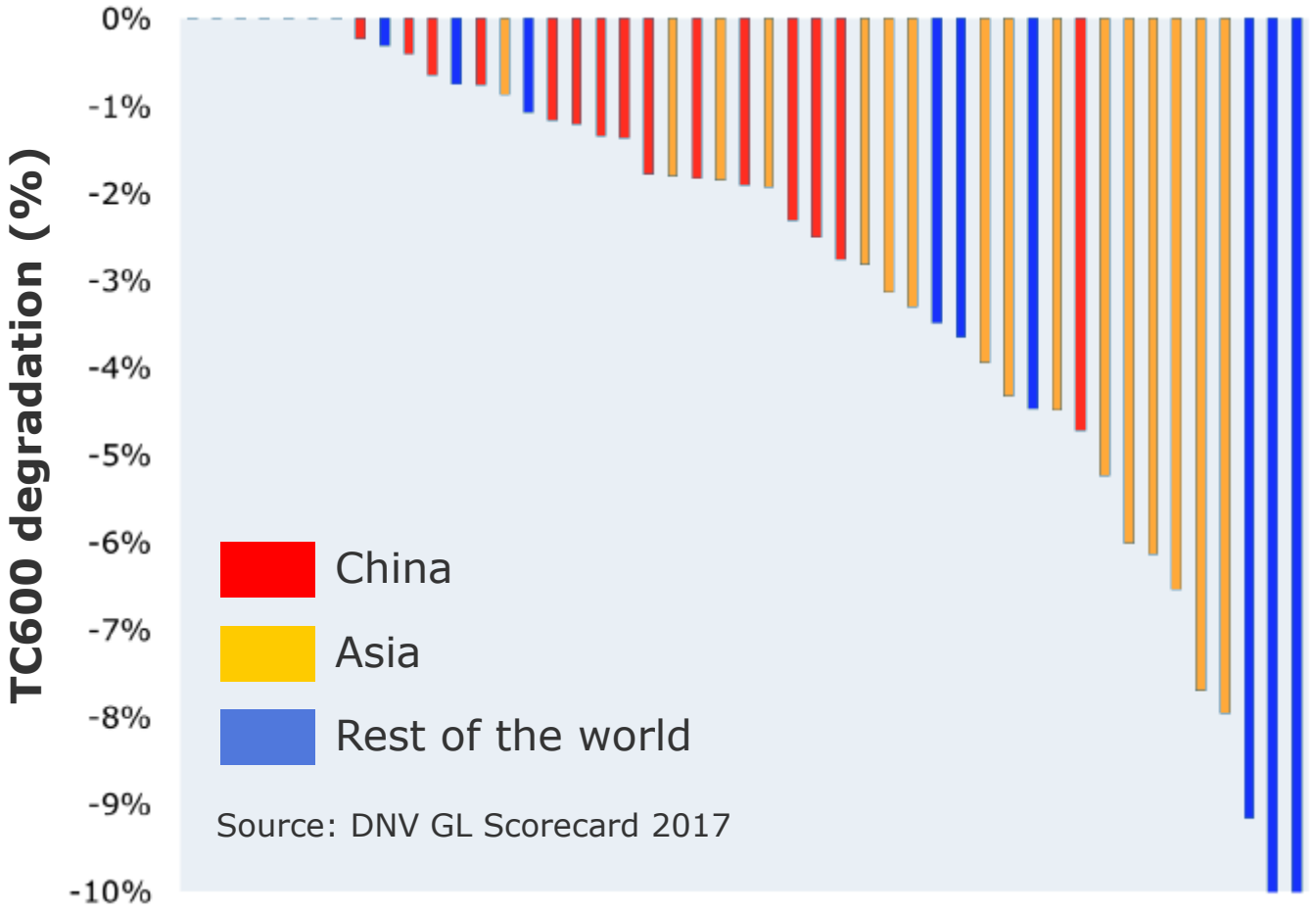
Key Finding 2 – Bill of Materials matters





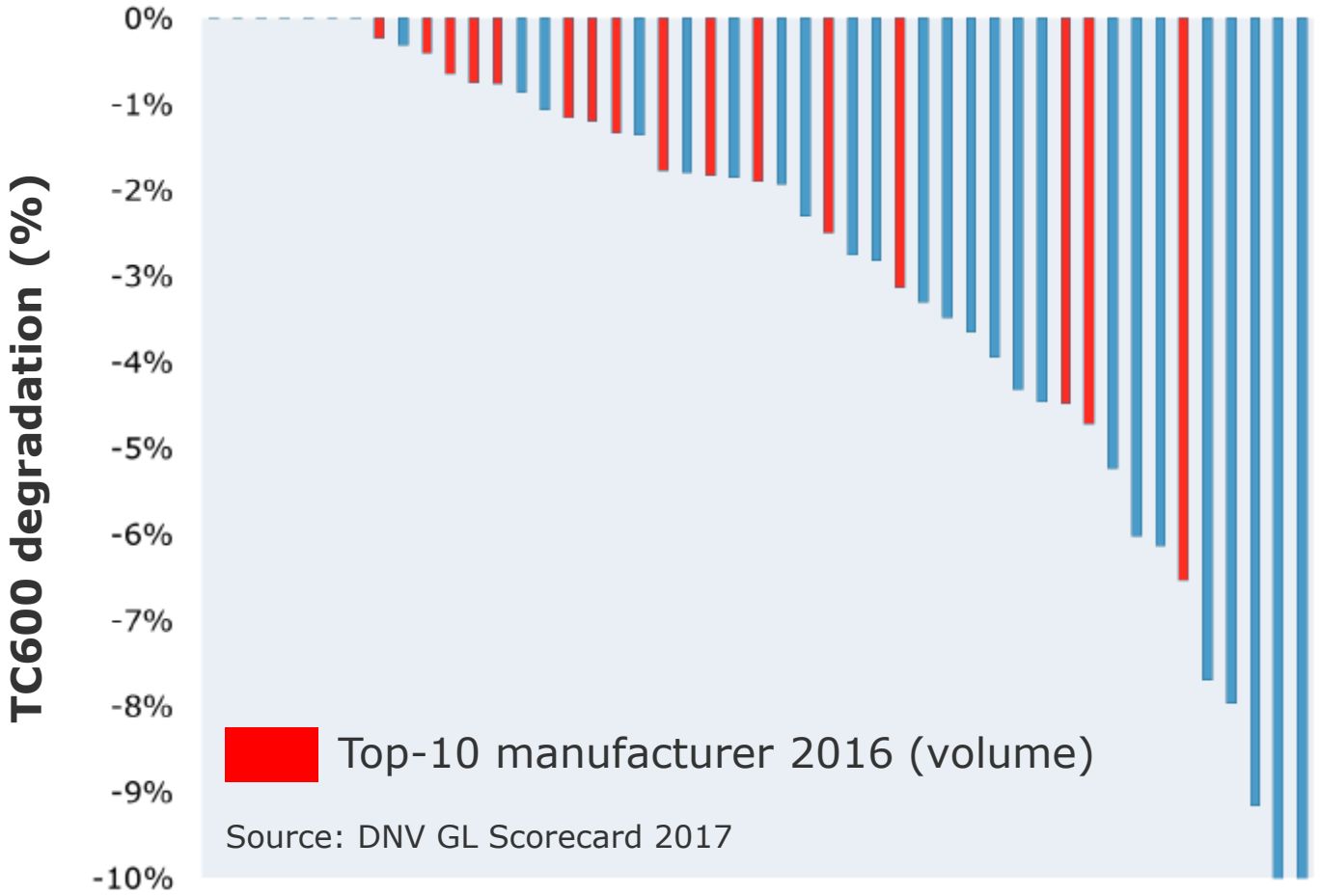
Different BOMs may result in different reliability testing

Key Finding 3 – Location is not a good proxy for quality



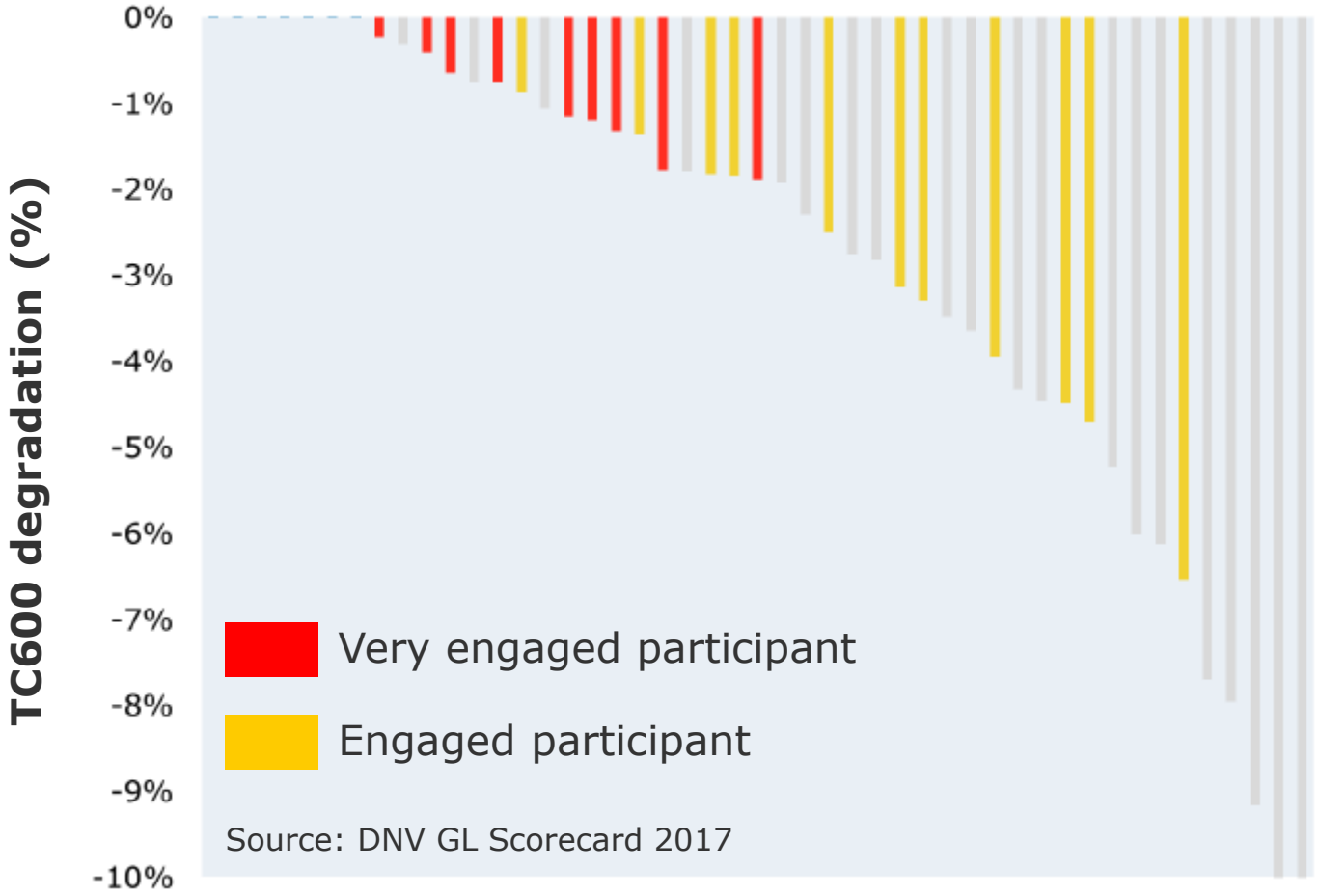
Some good and bad results in all regions of the world

Key Finding 4 – Manufacturing volume is not a proxy for quality



Big and small manufacturers show good and bad results

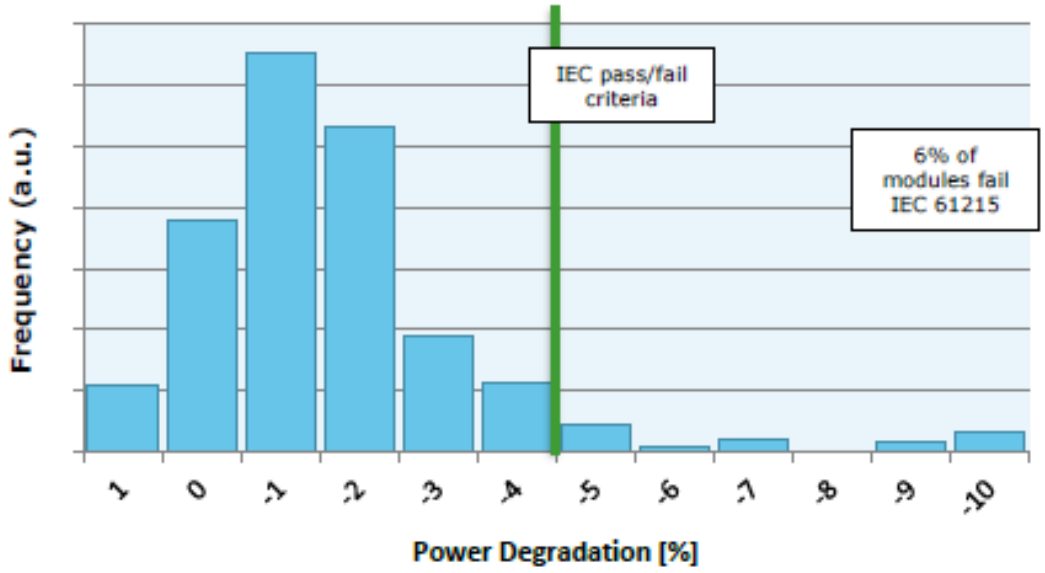
Key Finding 5 – Attention to quality matters



Reduce risks by choosing suppliers with 3rd party accelerated testing

Overall test statistics

Test	33rd percentile	66th percentile
TC 600 cycles	-3.0%	-5.9%
DML seq.	-0.9%	-3.4%
PID 600h	-1.1%	-5.6%
LID 40 kWh/m²	-0.9%	-1.5%



Conclusions

- The good news is that most modules perform very well under test, though even some "Tier 1" certified modules fail the baseline IEC 61215 tests in our lab

  WHY? Because we randomly select module samples for testing

- The bad news is you can't pick winners based solely on "Tier 1" status, factory location or manufacturing capacity

  WHY? Differentiator is the quality control criteria applied

- Insist on 3rd party accelerated test reports

  WHY? Today is not enough selecting certain product code

- Ensure the BoM proposed for your project is among the BoMs that performed well during the accelerated testing

  WHY? In that sense you have added confidence on the module and BOM purchased

Conclusions

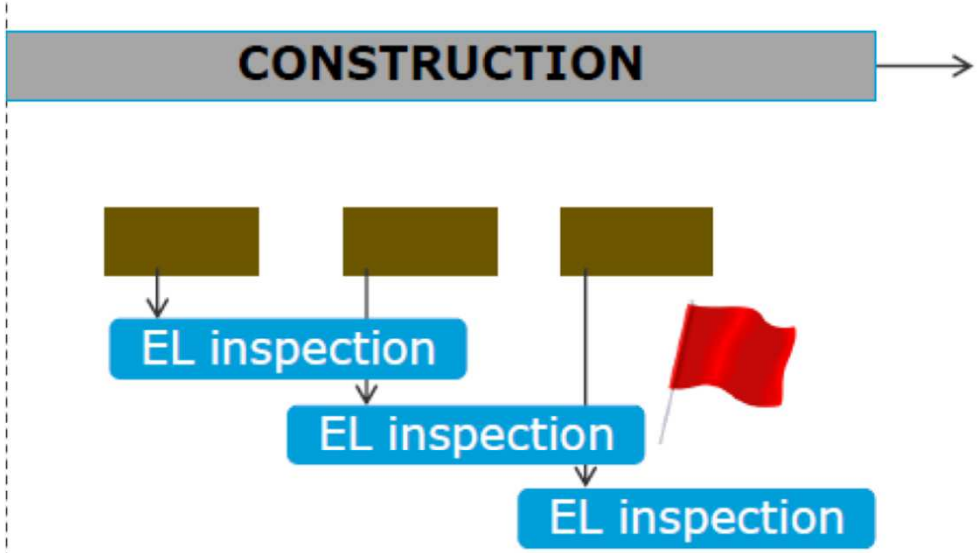
- Even with the rigor of a well defined product qualification approach, consider sample testing (e.g. statistical batch testing)

WHY? A small sample (e.g. < 0.1%) can be used to increase confidence that the entire batch meets design and quality requirements

Practical Implementation:

The DNV GL “Quality Option”

Best Practices Designed to Reduce Project Risks



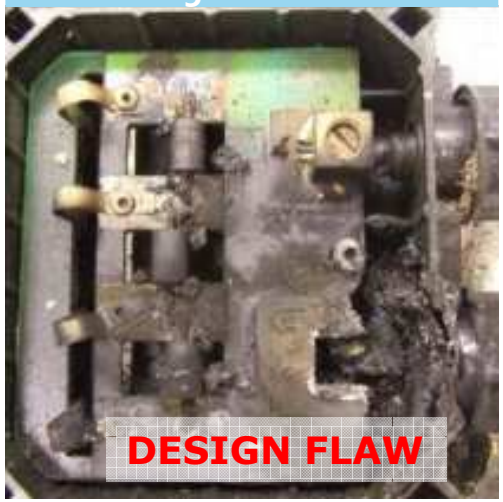
Field EL campaign:

- Representative (AQL) sample
- Post-shipment (compare to factory criteria)
- Post-installation (Compare pre- and post- installation)

PV Module Risks During Construction

PV Module Risks During Operation

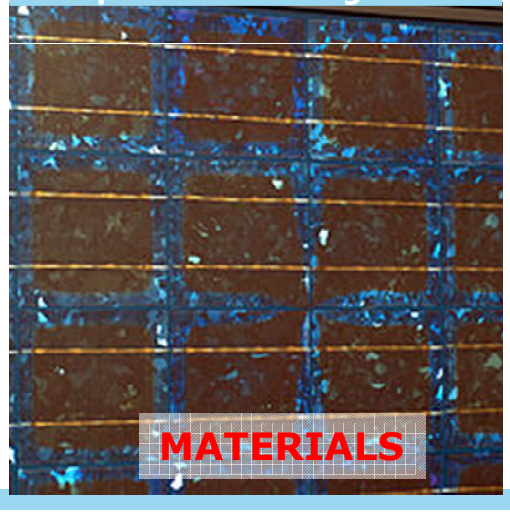
JBox Arcing



Solder Joint Degradation

Solder Joint Degradation

Encapsulant Browning



Backsheet Yellowing

Bubbles

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SAFER, SMARTER, GREENER