PVEL

MAKE DATA MATTER.

INSIGHTS FROM

THE 2021 PVEL PV MODULE RELIABILITY SCORECARD AND REC'S TEST RESULTS

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member of group kiwa

PVEL is the independent lab of the downstream solar & energy storage market and a member of the Kiwa Group

10+
Years of experience

500+
Bills of materials tested in the lab

400+
Downstream partners

30+GW
GW annual project pipelines supported

The 7th edition of the PVEL PV Module Reliability Scorecard is available now

PVEL

Introduction | Test Results | Top Performers | Why Testing Matters | Next Steps | Visit PVEL.com

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A Message from Our CEO

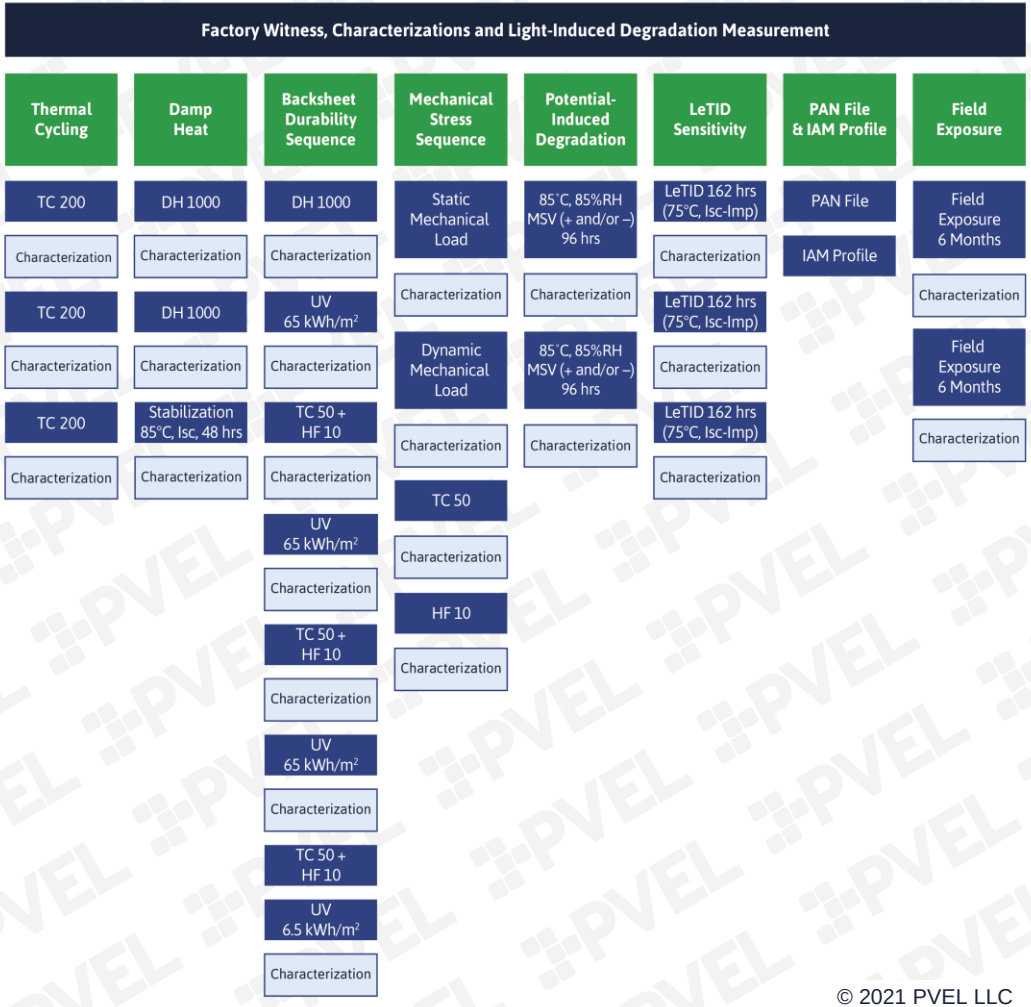
The solar industry has seen unprecedented growth in the past decade. The global manufacturing base has grown twentyfold, going from 20 gigawatts in 2010 to over 400 gigawatts today.

In a world of fake news, the challenge is finding the right data – the data that matters. Watch the video. I'll show you why.

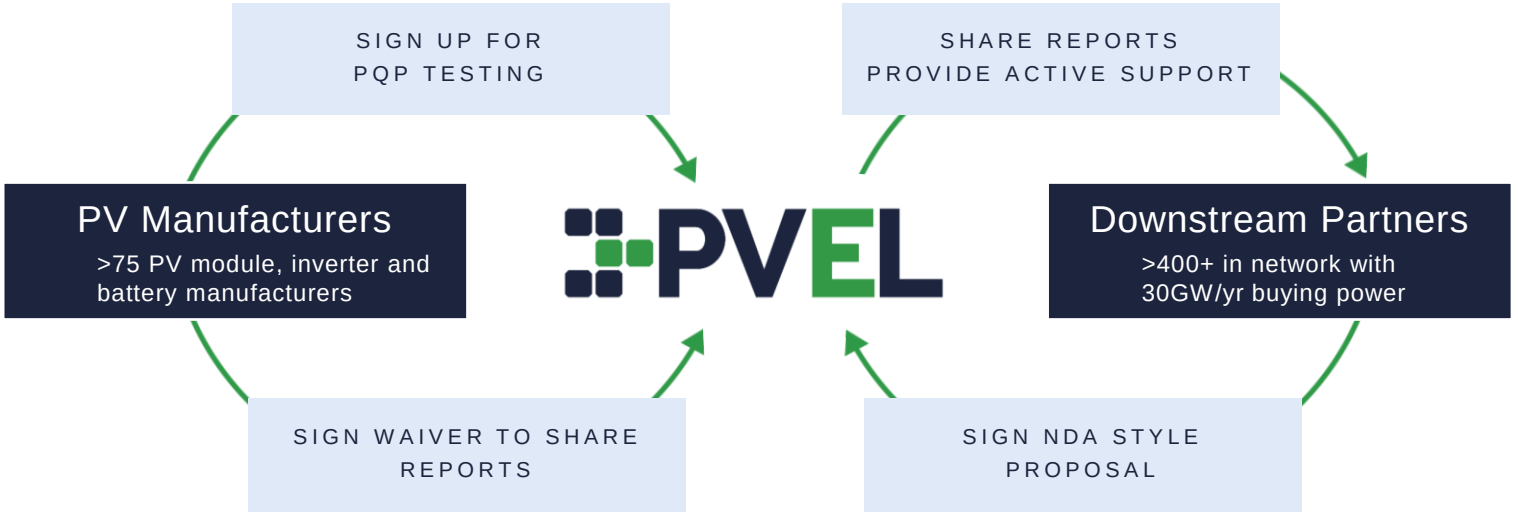
Jenya Meydbray, CEO
PV Evolution Labs

PV Module Production Qualification Program (PQP)

Our Scorecard summarizes test results from PVEL's PQP for PV modules

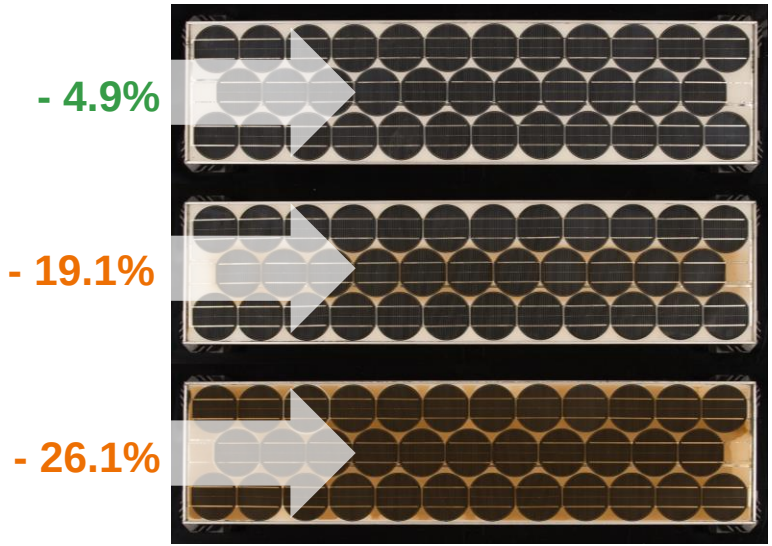


Our Scorecard is based on test results available in our PQP reports



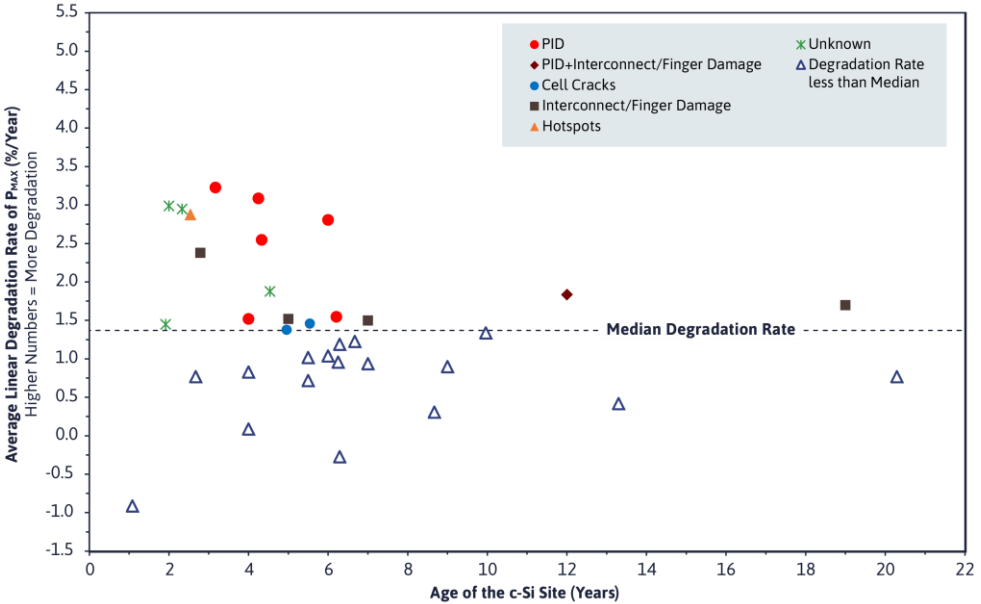
Field data informs our PQP – and drives buyer concerns – so data from the field is cited throughout our 2021 Scorecard

Dramatically different degradation rates after 35 years of field operation



Source: "35 years of photovoltaics: Analysis of the TISO-10-kW solar plant, lessons learnt in safety and performance—Part 2." Progress in Photovoltaics.

Newer PV modules have higher degradation rates



Source: Analysis of Field Degradation Rates Observed in the All India Survey of PV Module Reliability 2018", IEEE Journal of Photovoltaics

REC's History of Scorecard Top Performers

REC is one of only five module manufacturers who have appeared in the Scorecard six or more times.

These results demonstrate REC's commitment to reliability across many product generations.

- 2016: TP BLK
- 2017: TP BLK
- 2018: TP2
- 2019: TP2, TP2M
- 2020: TP2M
- 2021: Alpha, Alpha Black, TP3M

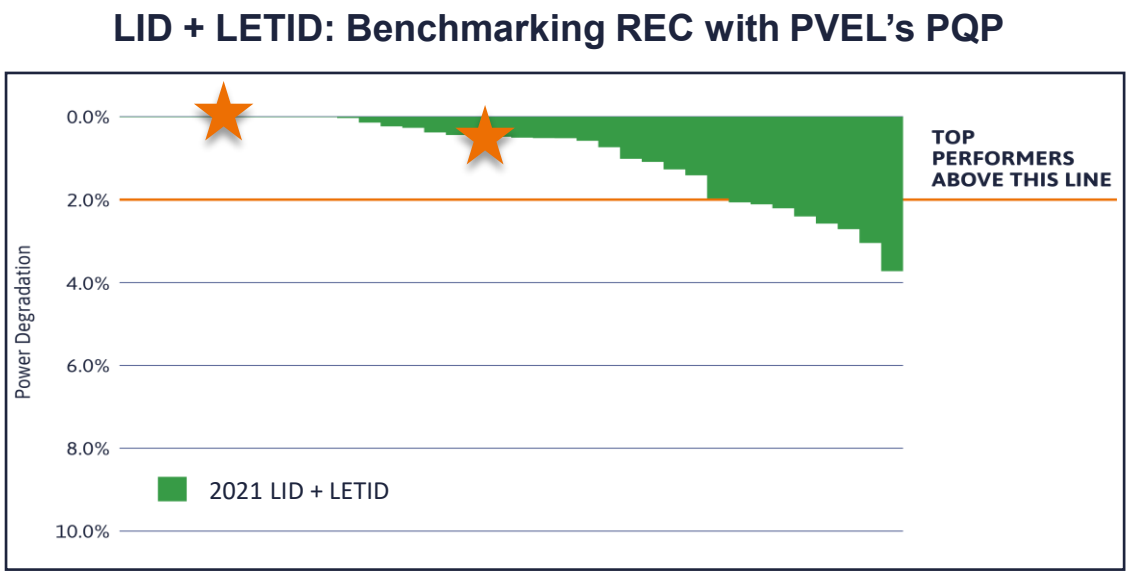
REC
SOLAR'S MOST TRUSTED

TOP PERFORMER 2021 PVEL PV MODULE RELIABILITY SCORECARD

- Future: Alpha Pure and TP4 (PQPs have been initiated)

LID + LETID Results

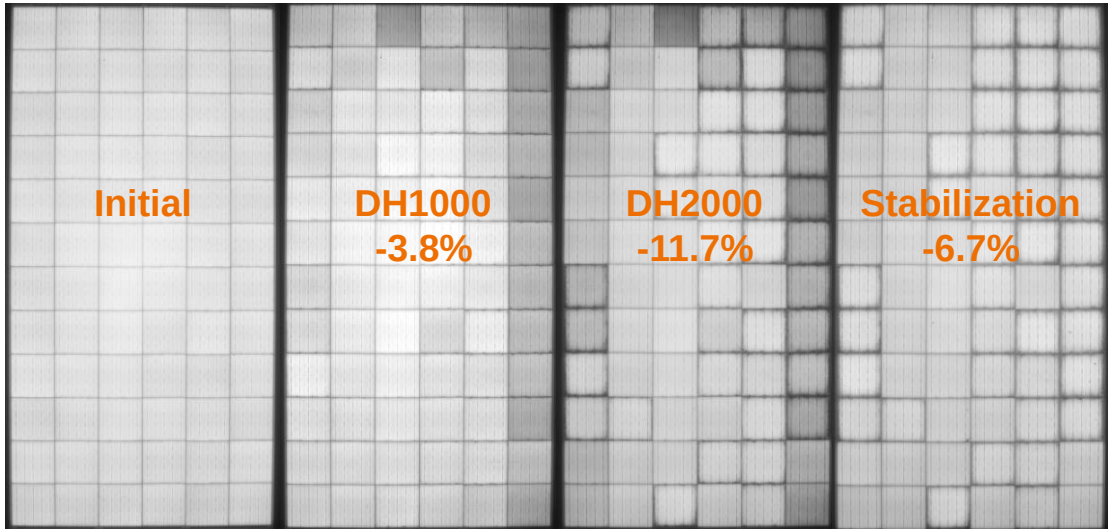
- Light-induced degradation plus light and elevated temperature induced degradation (LID + LETID) is a new Top Performer category in the 2021 Scorecard
- Benchmarking in the Scorecard helps increase understanding of these degradation modes:
  - The impact of LID on Al-BSF cells is well-understood
  - The industry lacks clarity for PERC technology, which is also affected by LETID



REC's Alpha Series and TP3M were LID + LETID Top Performers (actual results shown as stars)

Damp Heat Results

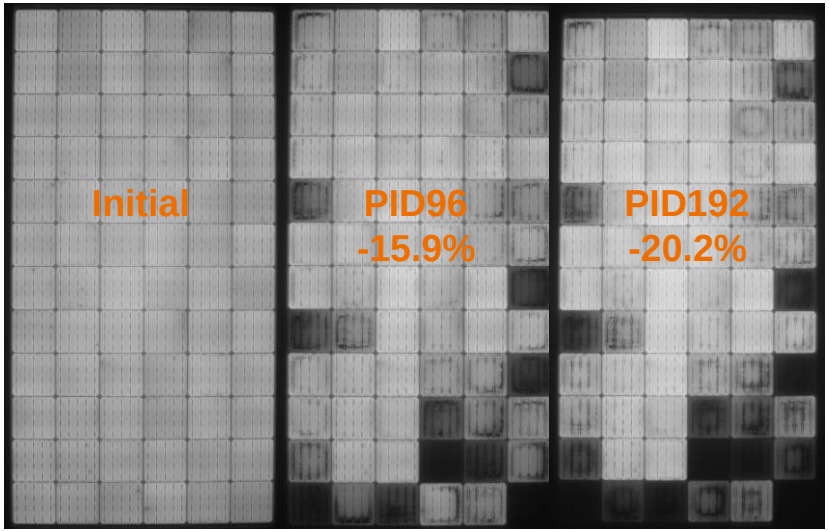
- PVEL's test results indicate that damp heat (DH) remains critical for identifying modules susceptible to moisture ingress as shown in this example. Testing is performed for 2000 hours at 85°C and 85% RH.
- REC achieved Top Performer status following DH2000 for TP3M and following stabilization for Alpha and Alpha Black.



vs.

Potential-Induced Degradation Results

- Many modules are advertised “PID resistant”, yet both the median and average degradation from PID for the 2021 Scorecard was the highest in PVEL’s history.
- REC achieved Top Performer status in the 2021 Scorecard for TP3M. Their Alpha results were released after Scorecard publication but were also well within the Top Performer threshold.



vs.

PAN Performance Results

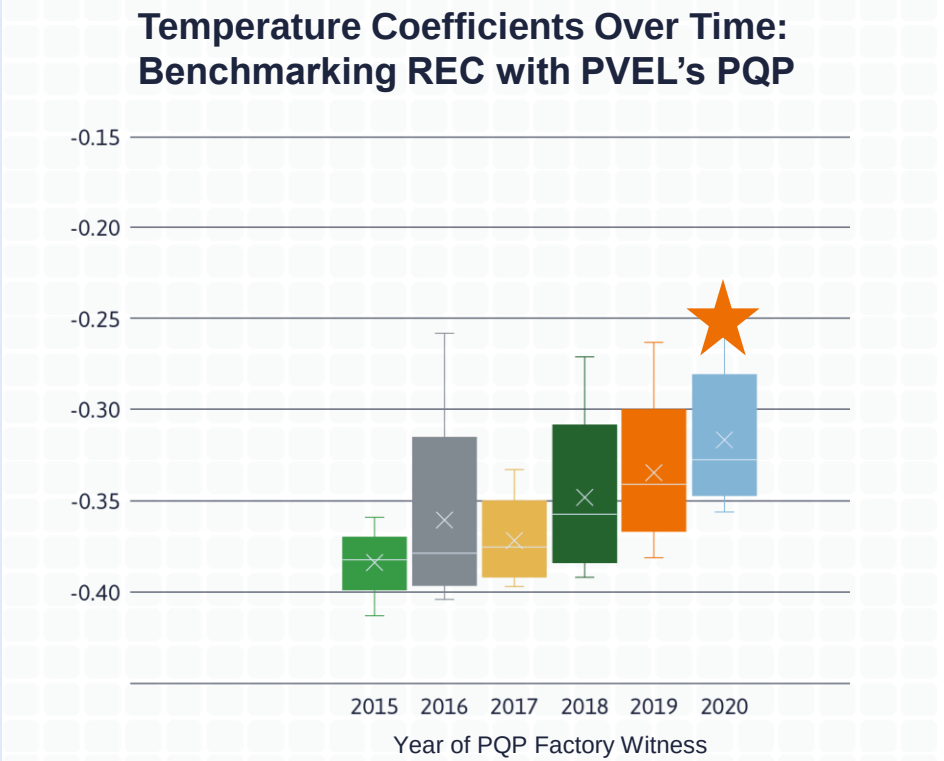
- To quantify module performance PVEL tests three identical samples across a matrix of operating conditions per IEC 61853-1:
  - A custom PAN file is created with PVsyst's model parameters optimized for close agreement between PVsyst's modeled results and PVEL's measurements across all conditions
- All 2021 Top Performers have bifacial designs
- **REC's Alpha was the highest performing monofacial in the 2021 dataset**

PAN: Benchmarking REC with PVEL's PQP

PVEL PAN file specific energy yield results for a simulated site located in Las Vegas. Historical results versus 2021 Scorecard dataset.

PAN Performance: Temperature Coefficients

- Module temperature coefficients continue to improve year over year, leading to increased power at higher temperatures
  - Improvements are most impactful for rooftop sites in hot climates
- REC's Alpha has achieved among the best temperature coefficients ever recorded at PVEL
  - The Alpha's heterojunction (HJT) cell design allows for improved temperature coefficients
  - This is the reason behind Alpha's strong results in the PAN Performance category



THANK YOU

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See the rest of the Scorecard at

modulescorecard.pvel.com

member of group

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