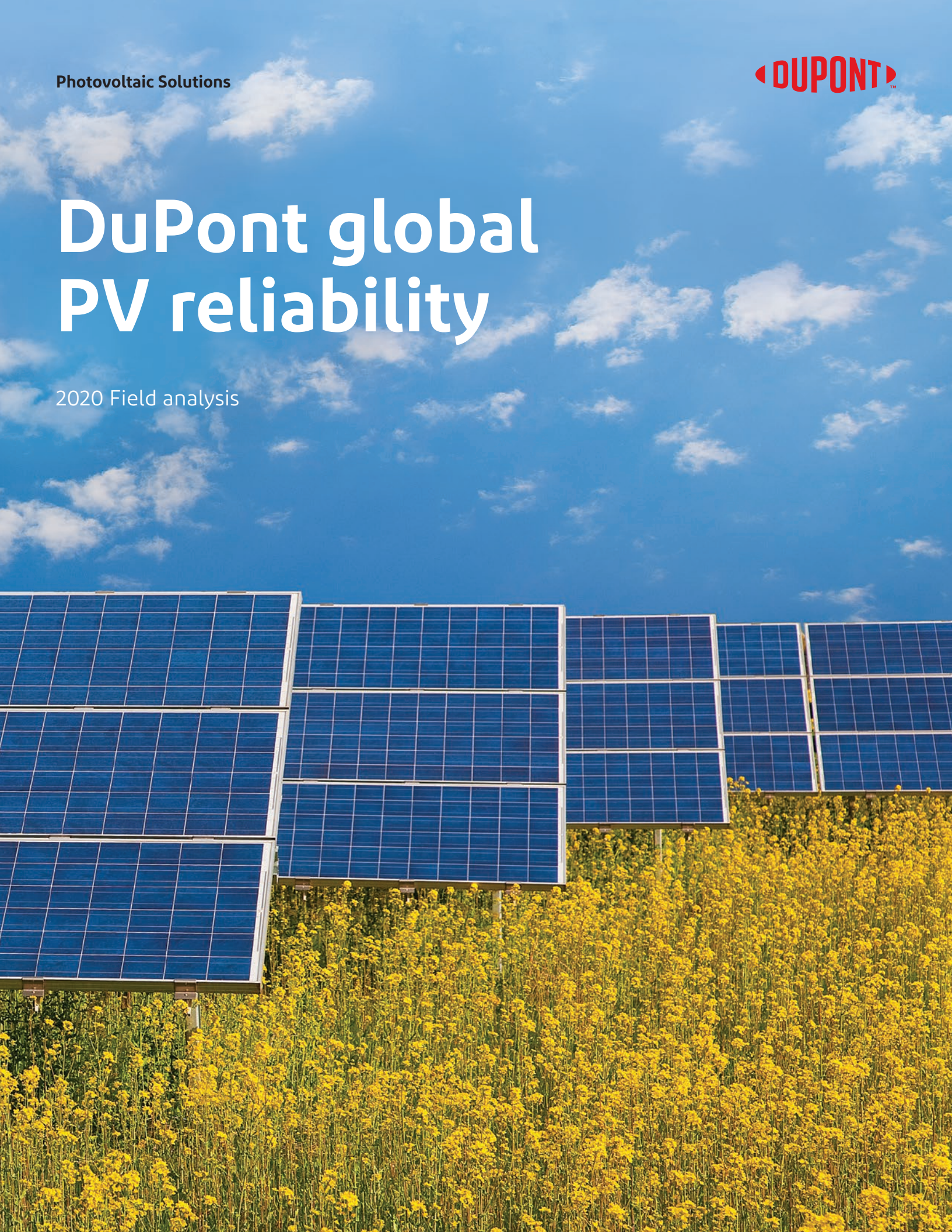
Photovoltaic Solutions

DUPONT™

DuPont global PV reliability

2020 Field analysis



Executive summary

The DuPont Global Field Reliability Program is a highly developed field inspection and analysis program that tracks material degradation and its effect on module performance.

This program is one of the most thorough of its kind, guided by a multistep inspection protocol at sites in North America, Europe, Asia, and the Middle East. Resulting data are analyzed using a variety of criteria—including component, material, mounting, time in service, and climate.

For nearly a decade, DuPont has collaborated with field partners, customers, downstream developers, universities, and national labs to perform these field inspections. Our mission is simple yet critical: to inspect, assess, and understand the state of degradation of fielded photovoltaic (PV) modules, in order to ensure that these modules will last long enough to reach the financial objectives of their owners.

This 2020 field analysis was compiled from inspection and analysis by DuPont teams of nearly 3GW of PV installations around the globe. It is offered as a current and reliable source to help buyers understand the breadth of component degradation issues and module failures that occur in the field.

9 M
Modules

551
Installations

3GW
Total power

While our field analysis looks at all component materials, we focus special attention on backsheet durability, which plays a critical role in significantly extending the life of photovoltaic modules and the solar plants where they're installed.

2020 Study results

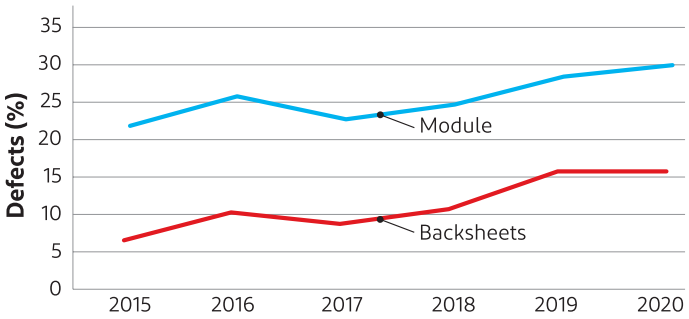
Inspection observations based on 3GW of fields:

- Total module defects: 30%
- Total backsheet defects: 16%
- Total cell/interconnect defects: 14%
- Cracking comprises 64% of all backsheet defects

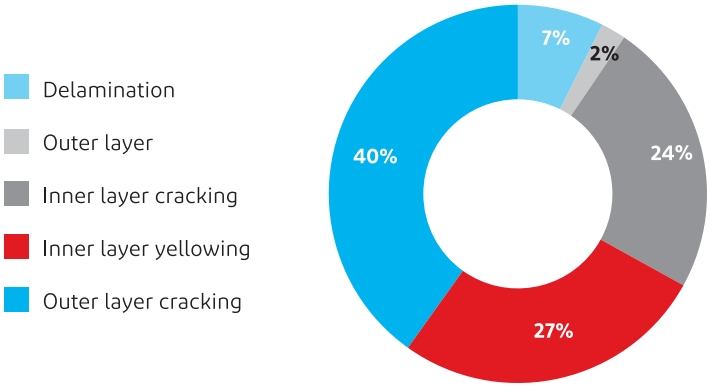
Module defect types

- Backsheet: outer-layer (air side) and inner-layer (cell side) cracking, delamination, yellowing
- Cell/interconnect: corrosion, hot spot, snail trails, broken interconnect, cracks, burn marks
- Encapsulant: discoloration, browning, delamination
- Other: glass defects, loss of anti-reflective (AR) coating, junction box

Defect trends



Backsheet defects by degradation mode



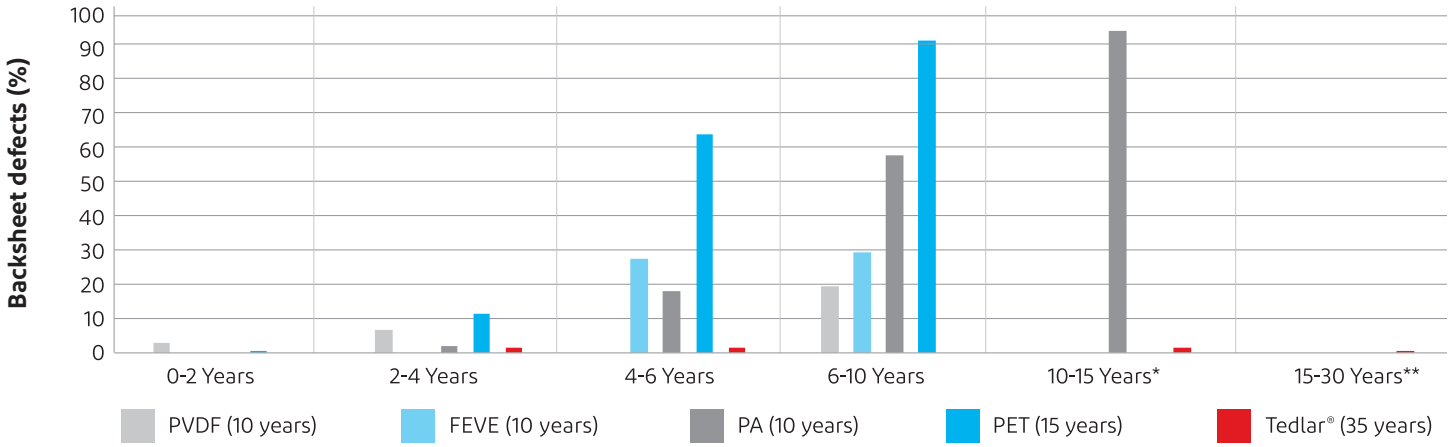
Emerging trends in backsheet failures

- Rapid increase in cracking in polyvinylidene fluoride (PVDF) backsheets
- Cracking of inner layers
- Delamination in double glass modules
- The overall PVDF outer layer cracking rate increased more than 3x
- The overall inner layer cracking rate tripled

Backsheet defect rates

DuPont™ Tedlar® polyvinyl fluoride (PVF) film-based backsheet maintains the lowest defect rates—even after 35 years in the field.

Defect rates in PVDF, FEVE, PA, PET and Tedlar® backsheets



PA = Polyamide
PET = Polyethylene terephthalate

PVDF = Polyvinylidene fluoride
FEVE = Fluoroethylene vinyl ether

*No PVDF, FEVE or PA backsheets in this age range exist in the field.

**No PVDF, FEVE, PA or PET backsheets in this age range exist in the field.

Backsheet field study key findings

2019 vs. 2020 overall findings

PVDF outer-layer cracking defect rates have increased more than 3x in the past year.

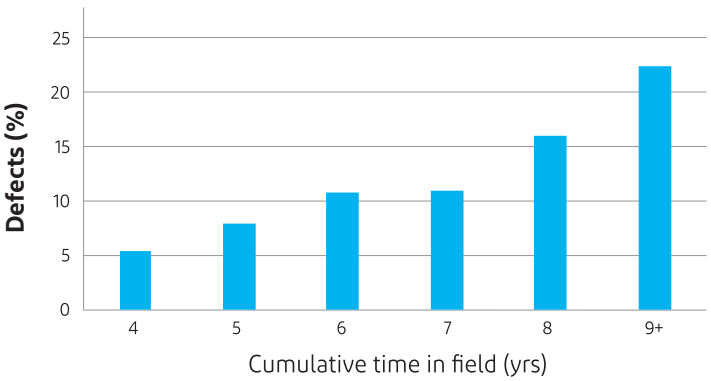
PVDF cracking in China, Europe, India, and North America

There is no clear correlation between cracking and climate because cracking has been observed in hot-arid, cold-arid, temperate, and Mediterranean regions.

Rapid increase of cracking in PVDF backsheets

There has been observed nearly a four-fold cumulative increase in PVDF outer-layer cracking defect rates, from 5% to 23% between year 4 and year 9 after installation.

PVDF backsheet cracking defect rate



Material defects

PVDF backsheet cracking

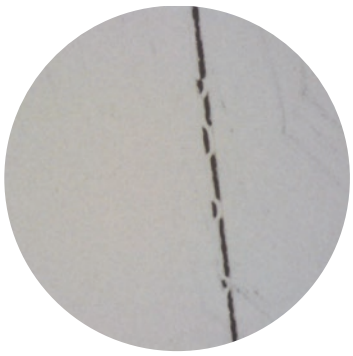
There have been observed many examples of widespread backsheet through-cracks.

• These failures are prevalent along busbar ribbons, but with continued weathering can extend to cell gaps and other regions.

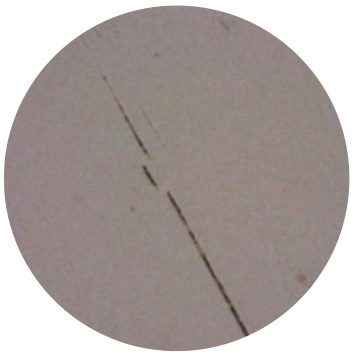
• Arcing and shorts often lead to localized burn-through and sometimes full module fires.

• Reported inverter tripping and ground faults.

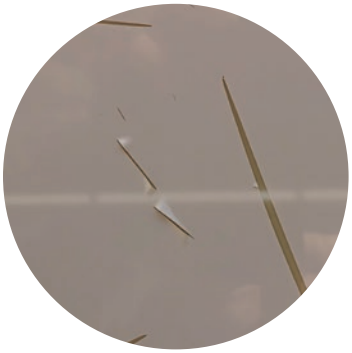
5 years
Eastern Canada



6 years
Qinghai, China



6 years
Xinjiang, China

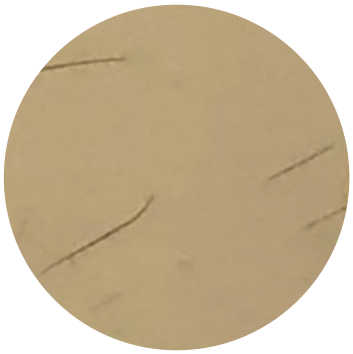


7 years
SW USA

8.5 years
Veneto, Italy

9 years
Apulia, Italy

9 years
Gujarat, India

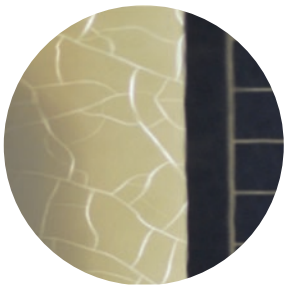


9 years
Telangana, India

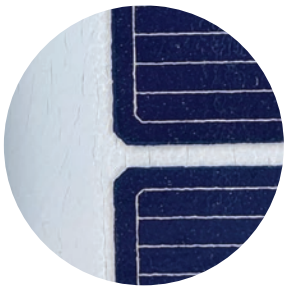
Inner-layer cracking

Inner-layer cracks were observed in multiple backsheet inner layers.

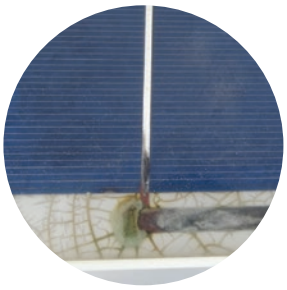
- These propagate through the module's polyester core.
- They are frequently encountered in FEVE and PET backsheets.
- They directly impact power and can cause delayed inverter starts, ground faults, and fires.



PET
6 years
Texas, USA



PET
6 years
Xining, China



FEVE
7.5 years
India

FEVE
8 years
Arizona, USA

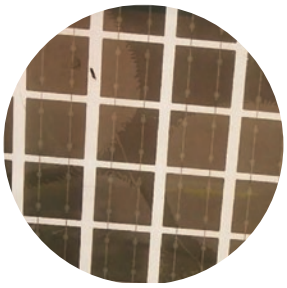
Glass backsheet defects

Delamination and cracking were observed in multiple glass backsheets.

- Delamination appears to originate near edges of a module or at individual cells.
- Cracks likely originate at scratches or chips on the glass surfaces and edges or at stress risers introduced by the racking system.

Glass/encapsulant delamination
8 years
West India

Delamination
9 years
SW USA



Delamination and cracking
10 years
SW USA

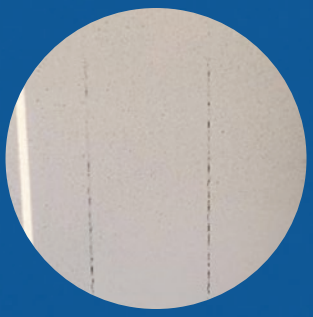
Delamination and corrosion
15 years
Southern China

Materials Matter™ when it comes to backsheets

Case study: France

A photovoltaic plant in France discovered that, after 8 years of use, performance of their modules was declining year over year and that many modules were displaying widespread backsheet cracking. This had led to a degradation of insulation resistance (IR) in the solar modules over time, leading to unsafe working conditions as a result of electrical hazards. All PA backsheets and 10% of PVDF backsheets exhibited cracking.

Widespread backsheet cracking
PVDF



Widespread backsheet cracking
PA

Case study: United States

One solar field in Arizona, USA utilized a mixed bill of materials. After 7 years of use, widespread cracking was found in PVDF backsheets. The entire field needed to replace modules in order to maintain operation and energy production and, as a result, sustained multimillion-dollar losses. No defects were observed in modules made with Tedlar® PVF-based backsheets.

Widespread backsheet cracking
PVDF

No defect
Tedlar® PVF

DUPONT™

To learn more about DuPont Photovoltaic Solutions, visit photovoltaics.dupont.com