Assessing underperforming assets

Dr. Lucie Garreau-iles
Regional Technical Manager, EMEA
DuPont Photovoltaic Solutions
Lucie.garreau-iles@dupont.com

DuPont Photovoltaic Solutions

DUPONT™

DuPont Global Field Reliability Program

- Quantitative analysis: components, materials, age, failure mode
- Post-inspection analytical characterization
- Collaborative: field partners, developers, government labs, universities

Improved accelerated tests and informed materials selection

9 MM
modules

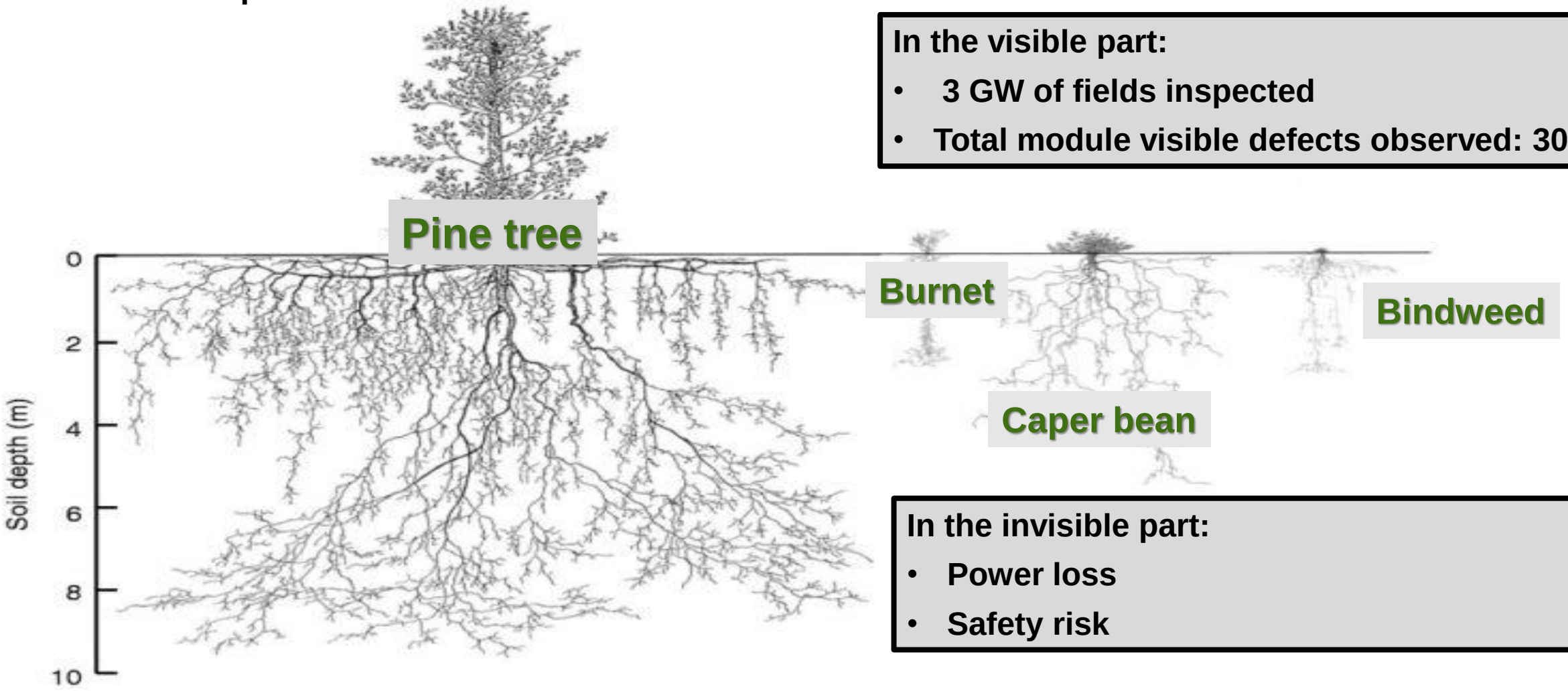
551
Installations

3 GW
modules

DUPONT™

Panel level degradation: issues and impact

PV panels can degrade faster than expected after only a few years of operation, leading to material failures and power loss



In the visible part:

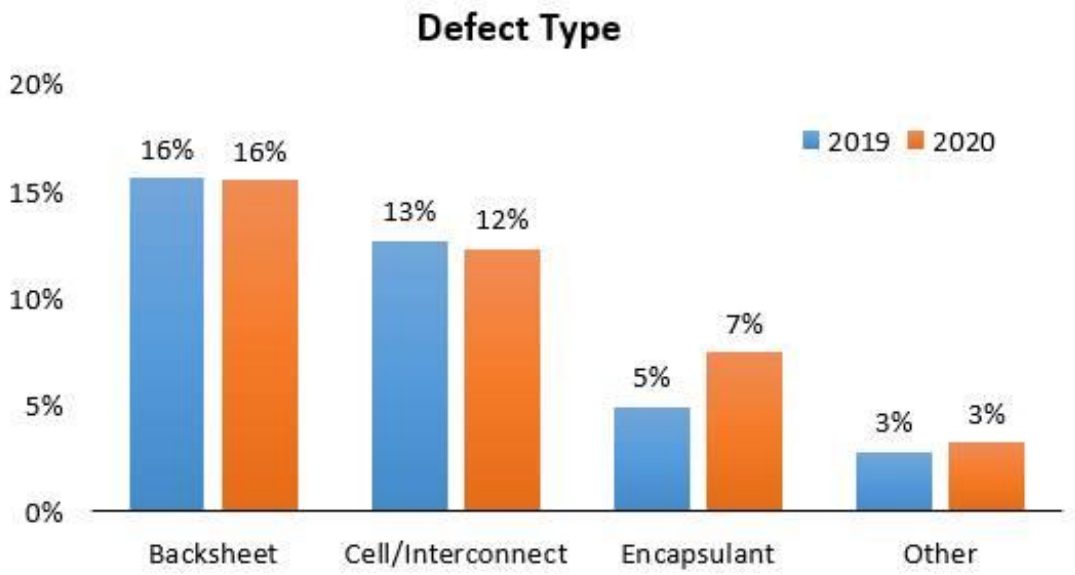
- 3 GW of fields inspected
- Total module visible defects observed: 30%

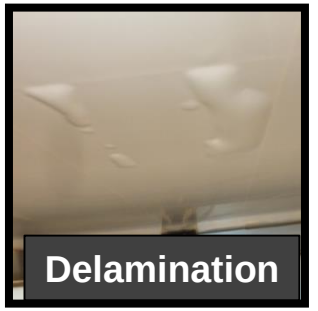
In the invisible part:

- Power loss
- Safety risk

DUPONT

The visible part of the system





In 2020, 30% of the panels DuPont inspected (3 GW) suffered from some type of visual degradation.

The invisible part of the system

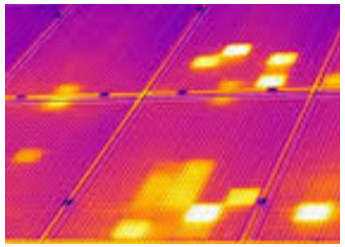
- **Typical issues invisible to the naked eye:**
- Broken cells
- Potential Induced degradation (PID)
- Defective diodes
- Increased contact resistance (busbars)
- Increased shunt resistance (cell degradation)
- Loss of dielectric protection (ground faults, current leakage)
- Optical degradation (partly visible, partly not)

- **All of these will have an impact on either:**
- Safety (and ultimately power if stopped to operate)
- Power

DUPONT™

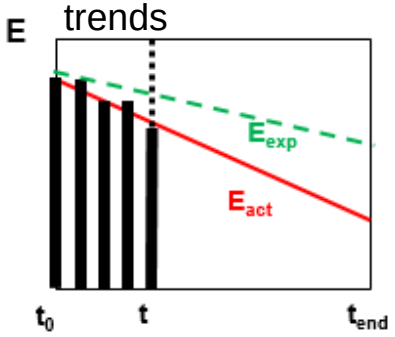
Detecting panel degradation: a multimodal approach

Thermal Anomalies



Panels affected by thermal anomalies are a large contributor to power loss

Power data analysis can shed light on quantitative historical losses and trends

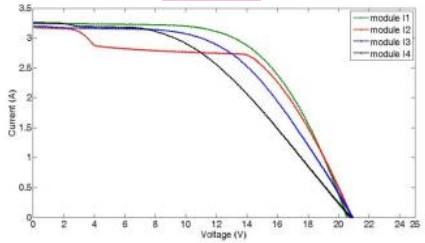


Historical/Trend Power Data

Visual inspection & lab analysis can determine and confirm the nature of degradations and safety risks

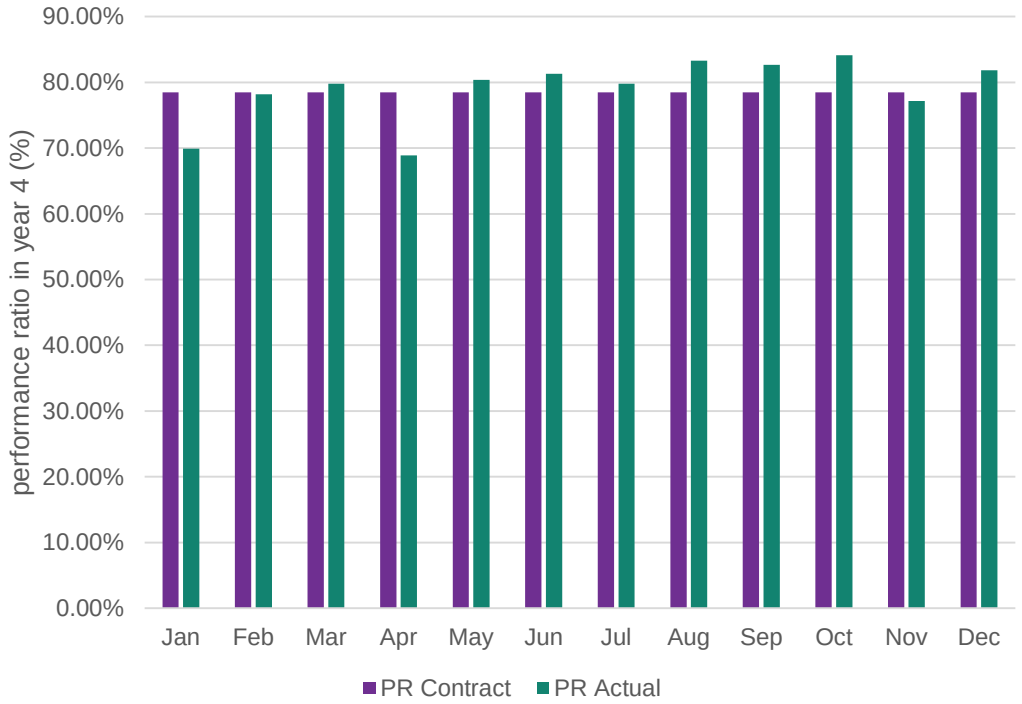
Visual & Lab Analysis/Safety

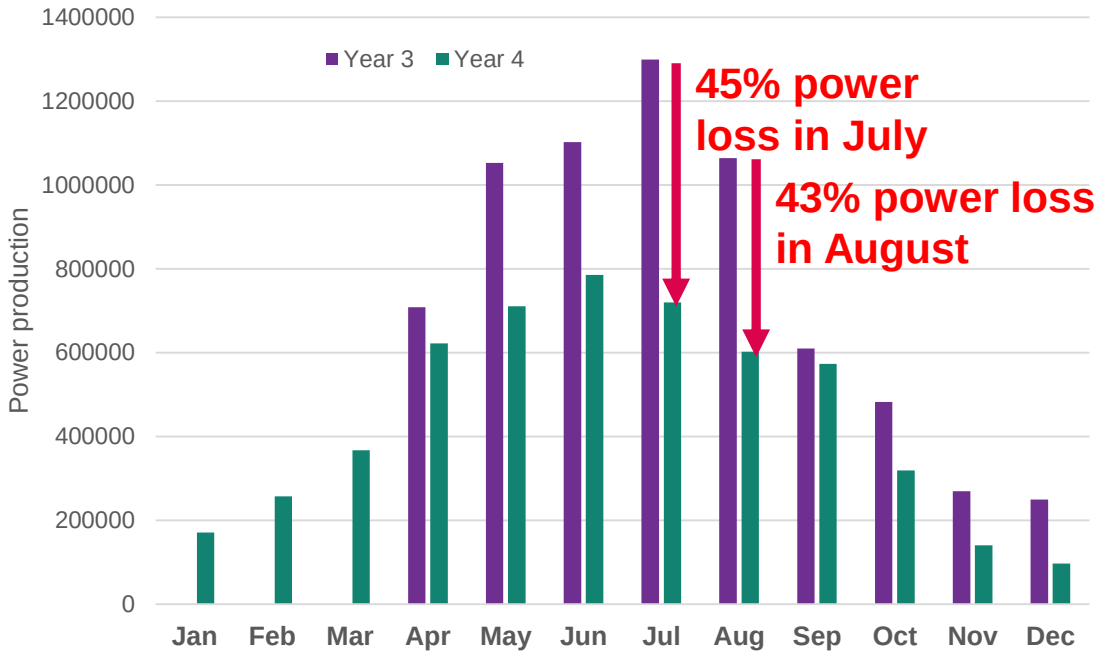
Gradual loss can be quantified by IV measurements, compared to nameplate power



Electrical IV: String/Panel Level

Case 1: one case truly invisible



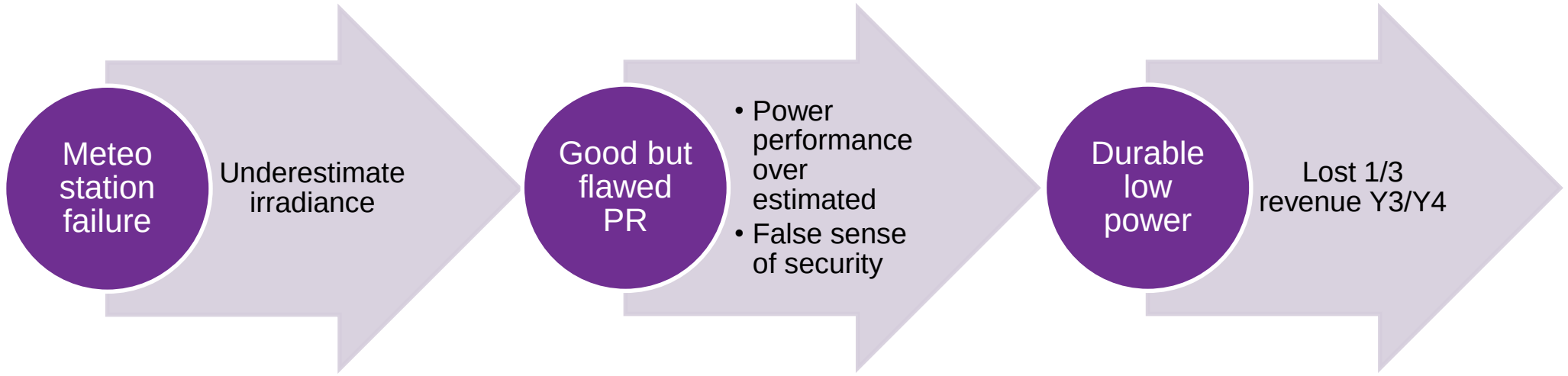


The performance ratio appears good in year 4. The annual PR average is about 78.95% for a target at 78.5%.

However, the revenue stream from the plant fell off. By 45% in July and 43% in August between year 3 and year 4.

PR: reference yield/specific yield
Reference yield= cumulative in-plane irradiance over a period of time

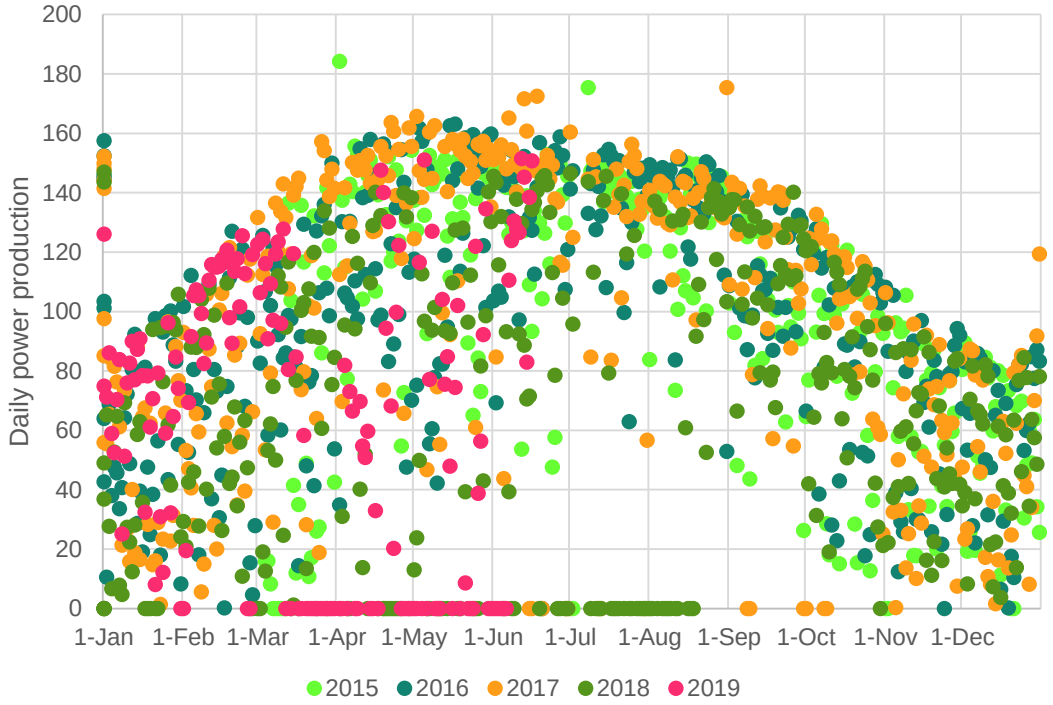
Case 1: chain reaction

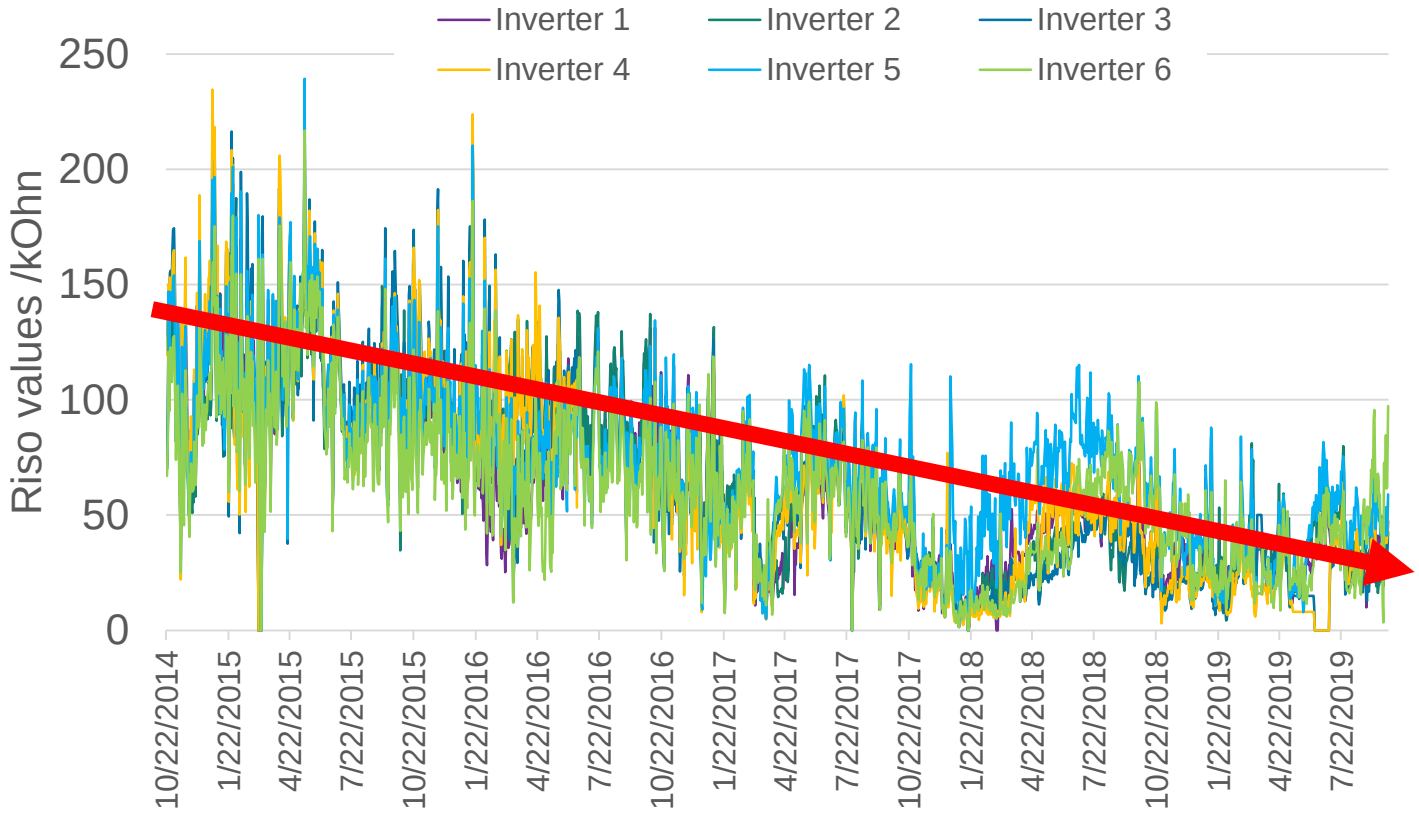


The problem?

- **DuPont diagnosed Potential Induced Degradation (PID) on this plant.**
- **This problem is reversible and easily fixed with minimal investment.**

Case 2: when safety threatens operation

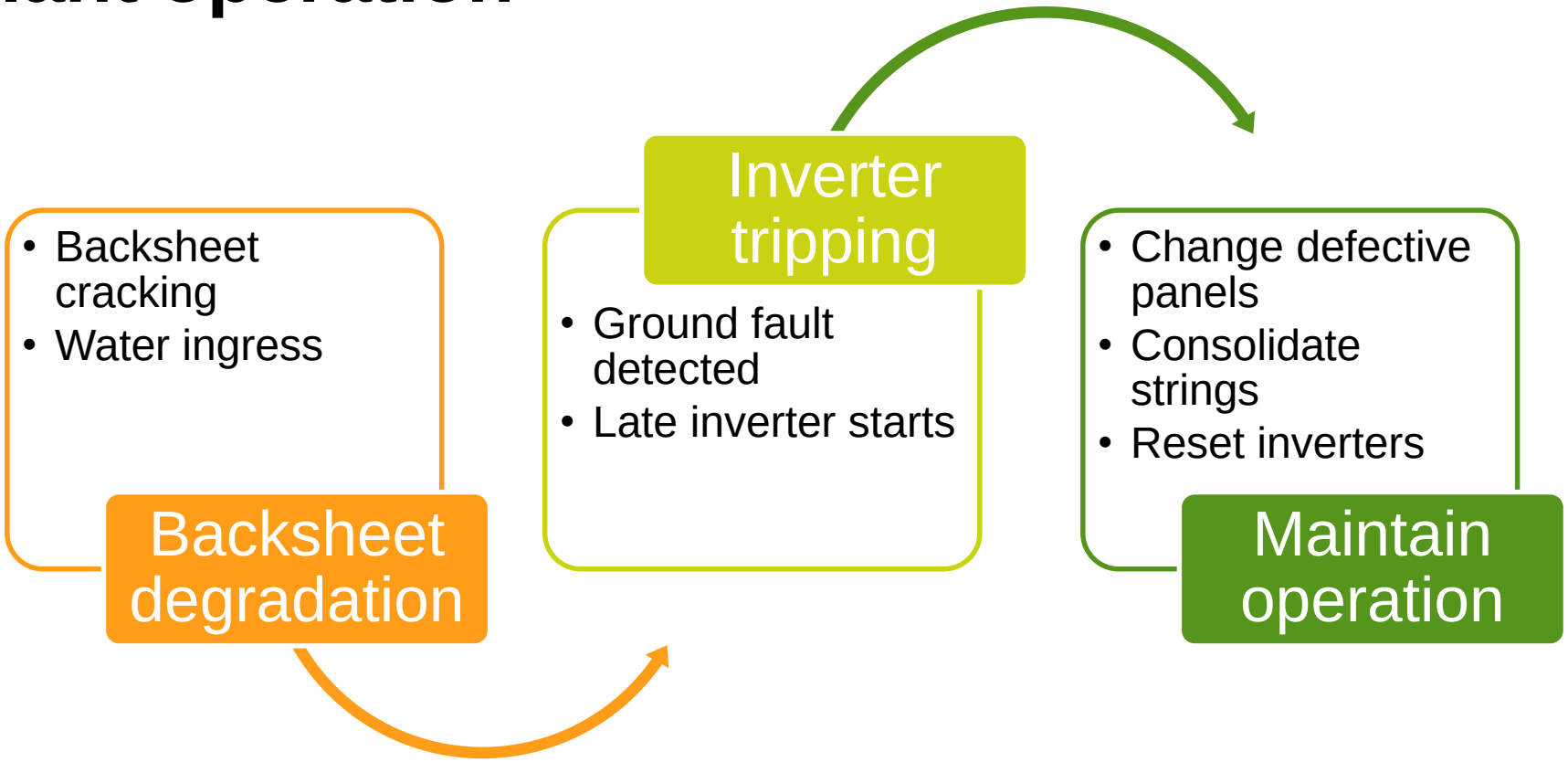




The plant is able to produce the same power Year-on-Year.

But, Insulation Resistance (R_{iso}) degraded over time.

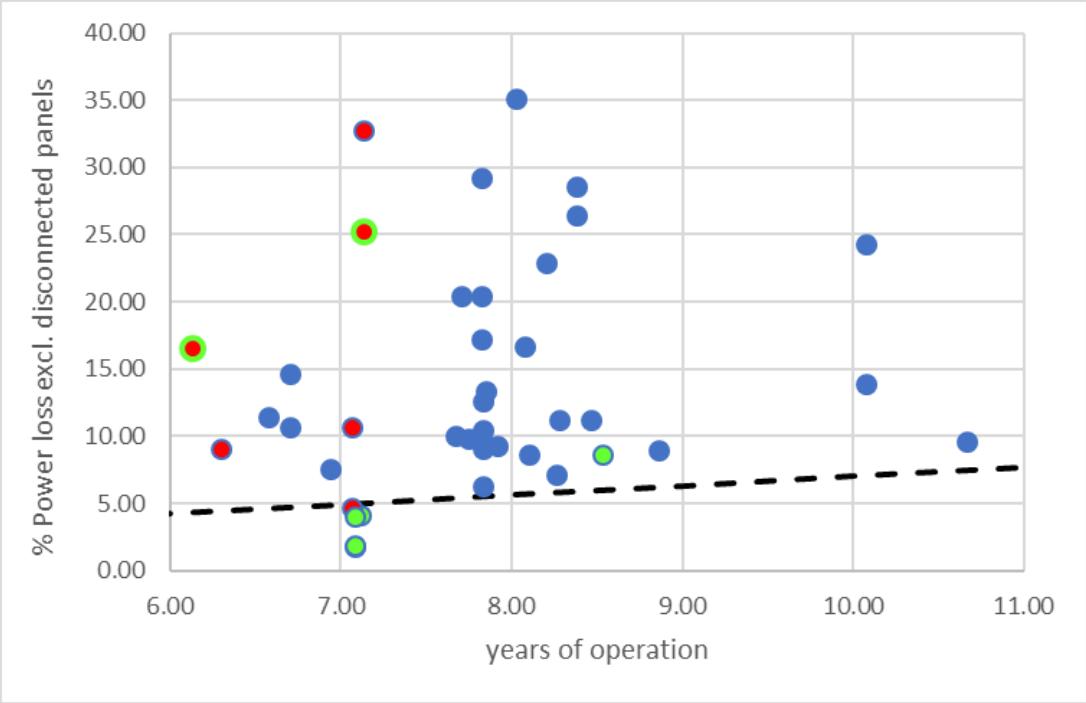
Case 2: safety is an underlying legal requirement for ANY plant operation



This plant did not lose power

… at a big cost to operation

Case 3: Panel degradation analysis on a large portfolio



13 different panel manufacturers, installations all in the Mediterranean region

Green: rooftop installations
Red: thin film
Blue: crystalline silicone, ground mounted
Black line: expected normal degradation

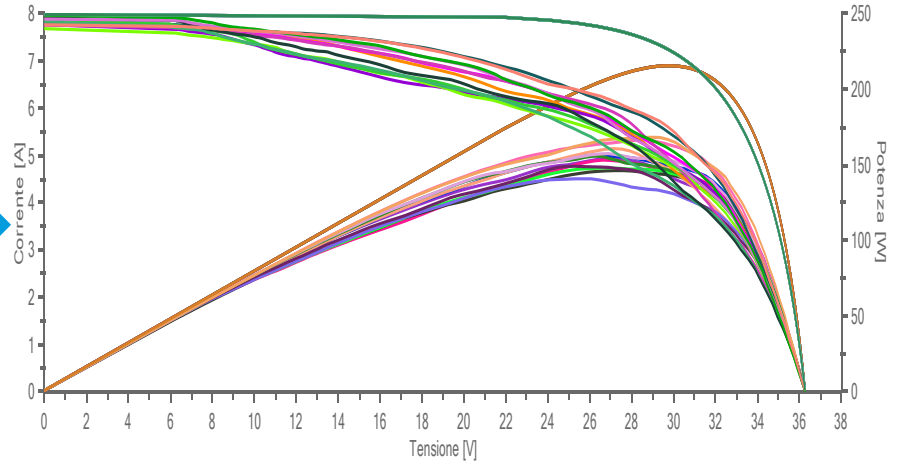
About 4 installations out of 40 fulfill normal degradation criteria (0.7% average).

Problems detected:

- Broken panels
- Broken cells
- Potential Induced Degradation (PID)
- Triggered bypass diodes
- Disconnected panels
- Cell degradation
- Panel materials degradation (light obscuration)
- Panel materials degradation (backsheet cracking)

Many installations displayed more than one problem

Case 3: one example - careful consideration of all the data



19.5% hot spots

100% cracked cells (snail trails)

19.35% power drop

There is often no direct relationship between the thermal image and the power loss measured – WHY?

1. You need to ensure you have no impact of vegetation when you perform the IR.
2. IR is often done with current state of soiling, which influences hot spots.
3. You need the right IR resolution to have adequate diagnostic power.
4. When performing IV testing, you will want to take out the effect of soiling.
5. Panel level degradation does not tell you its impact on the string performance.
6. Your panel degradation may be a combination of effects such as broken cells and PID.
7. Ensure you identify all of your defects by IR, visual and IV. Cross-matching data is crucial to getting the full picture.

Summary

The first and foremost condition of operation is SAFETY.

- Safety should not be taken for granted.
- The safety risk should be re-evaluated periodically according to the condition of the plant.

Once safe operation is assured, performance becomes the key parameter underlying the health of the investment. Key questions should be answered:

- Is my PR reliable (check weather station)?
- Is my monitoring system really telling me everything I need to know with regard to plant performance?
- Could my plants be performing better?