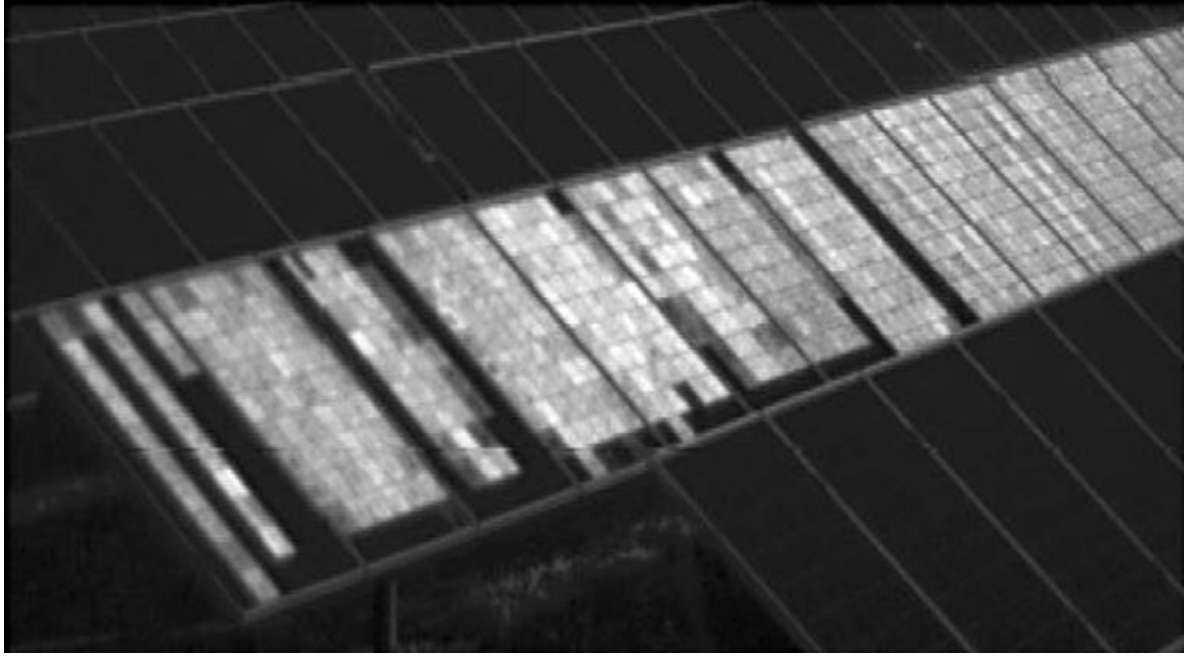


# PID in PV Power Plants

**PV Magazine Webinar on PID**

Dr. Lars Podlowski
VP Global Technical Services
PI Photovoltaik-Institut Berlin AG

# Overview

- PI–Berlin
- What Kind of PV Power Plants are Most Affected by PID
  - How conditions do influence PV Module sensitivity to PID
  - What kind of locations are more critical than others
- Detection of PID in the Field
- Preventive Measures against PID
  - Already PID-affected Power Plants
  - New Power Plants

- ANNEX: How „PID-safe“ is „PID-safe certified“ Panel really

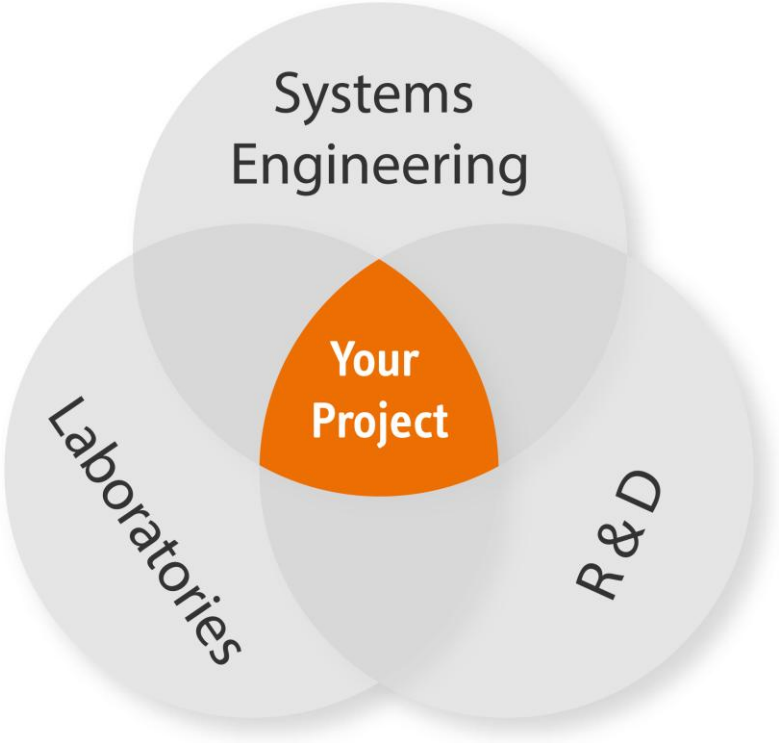
# Customer-oriented Independent PV Experts

From solar cells to the power plant, PI Berlin supports your solar project as a **customer-oriented independent expert since 2006**.

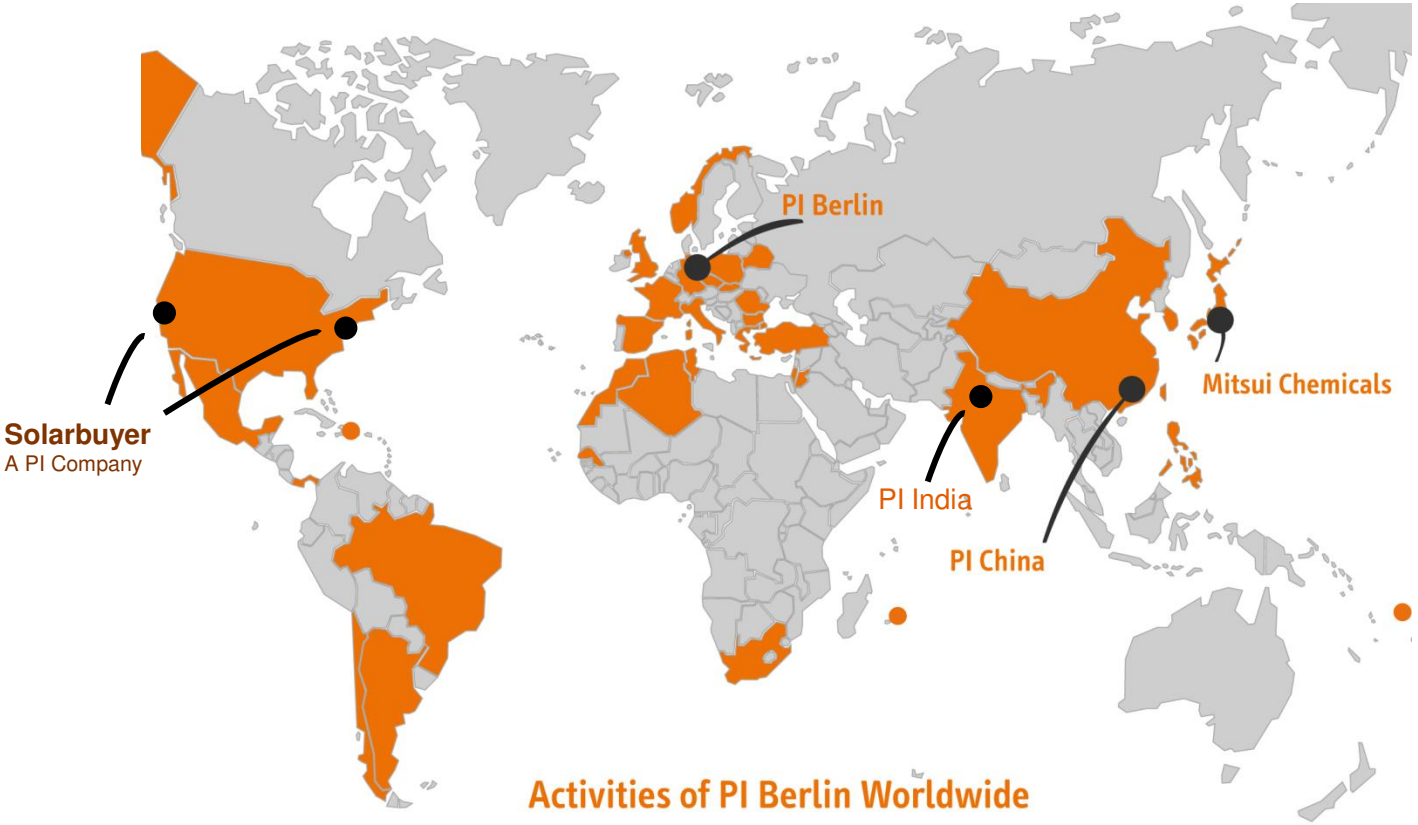
With our international team of experts, PI Berlin provides a wide spectrum of inspection, planning and consultation services. The core of our work is the **implementation and quality assurance for complex PV projects**.

We also have a PV systems team which

1. provides any kind of engineering services for PV power plants
2. is specialized in field failure analysis



# International Presence and Activities

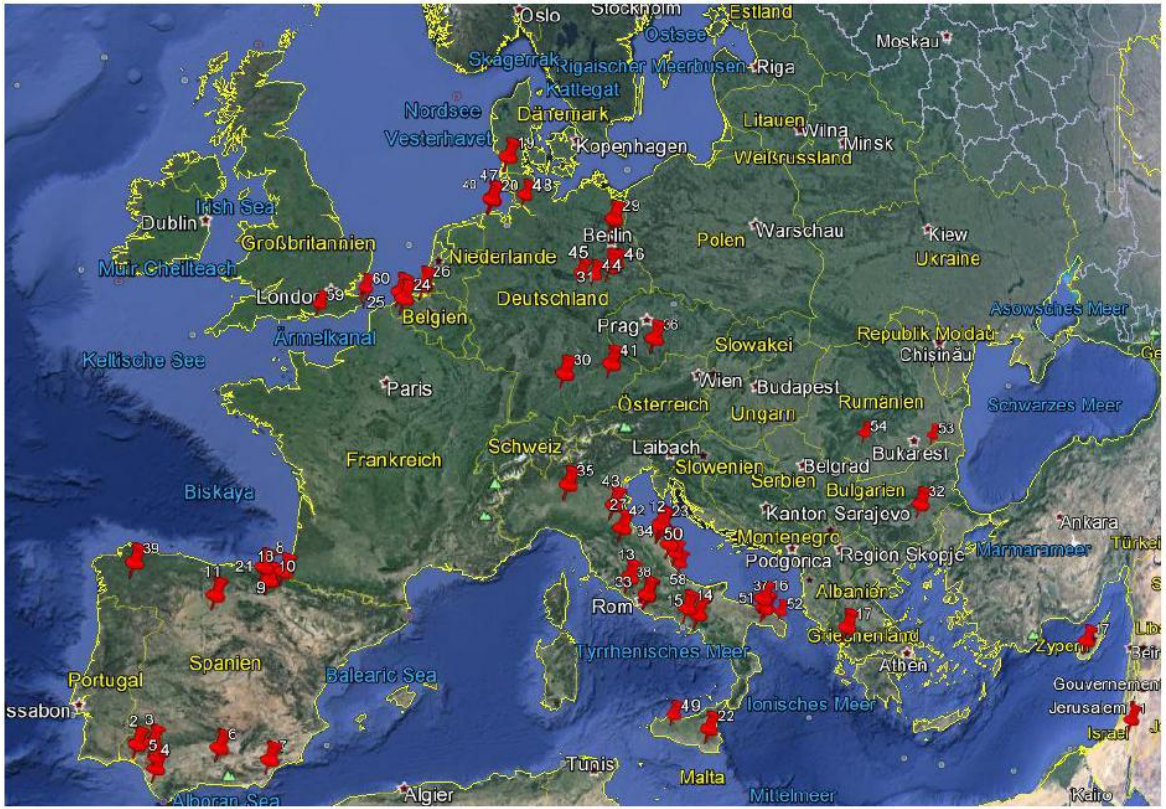


# What Kind of PV Power Plants are most Affected by PID

## How Conditions do Influence PV Module Sensitivity to PID

| Variable Parameter | Effect on PID | To remember |
|---|---|---|
| Temperature | The hotter the stronger | Heat is bad |
| Humidity | Water is supporting leakage current | Humidity is bad |
| Soiling | In case of dust on the panel PID is enhanced. | Dust is bad |
| Light intensity | The more light intensity the slower PID occurs | Light is good |
| Voltage level | PID only occurs under negative voltage | Negative Voltage is bad |
| Tilt angle | Low tilt angle leads to more accumulation of dust and longer presence of water (at lower edge) | Large tilt angle is good |

# What Kind of PV Power Plants are most Affected by PID




**PV power plants are more at risk**

- if located in warm/hot climates
- if located in humid environments (→ at the coast)
- at higher system voltages

- The very first field where PID ever got observed was on the island of Mallorca (panels by SOLON; cells by Q-Cells)

# Detection of PID in the Field

PID leads to a reduction of the solar cell efficiency. This means the solar cells have higher intrinsic losses and less effective electronic transitions within the semiconductor material.

# Detection of PID in the Field

PID leads to a reduction of the solar cell efficiency. This means the solar cells have higher intrinsic losses and less effective electronic transitions within the semiconductor material.

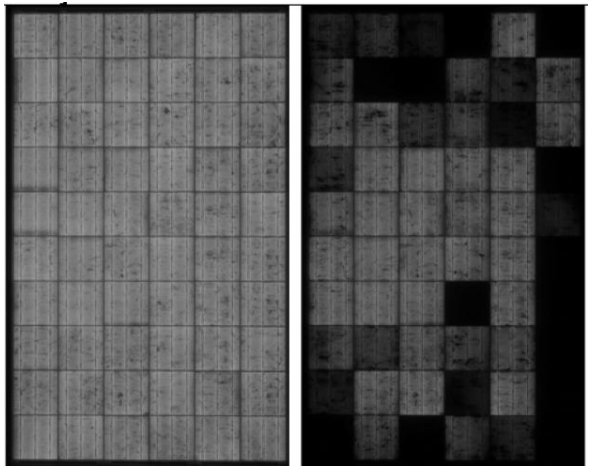
→ *production of heat*

→ *less emitting radiation under current*

1

2

**Graphik**



**Same panel before and after degradation.**

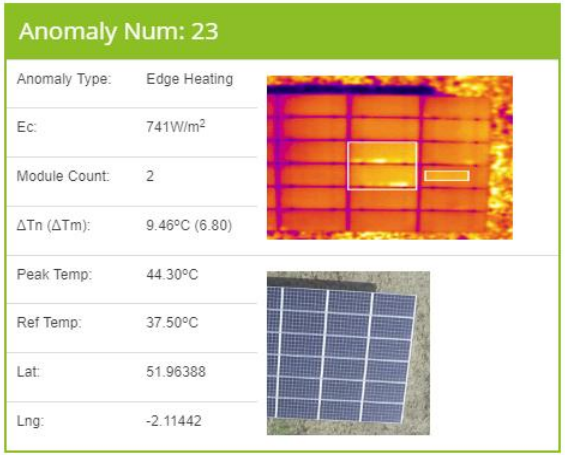
*The more PID the hotter the cell.*

*The more PID the darker the cell.*

# Detection of PID in the Field

1

Infrared imaging during operation




- Quick and simple to excecute
- For large fields a drone can be used
- Cheap: < $ 1,000 per MWp
- DIY possible by using IR camera for cell phone

2

Electroluminescence (at night)

**Graphik**

- Difficult to excecute (darkness; strings to be electrically accessed; special camera)
- Costs > $ 10,000 per MWp
- Much better accuracy than IR

# Detection of PID in the Field

By IR and EL imaging only qualitative statements are possible – no actual module STC power can be derived.

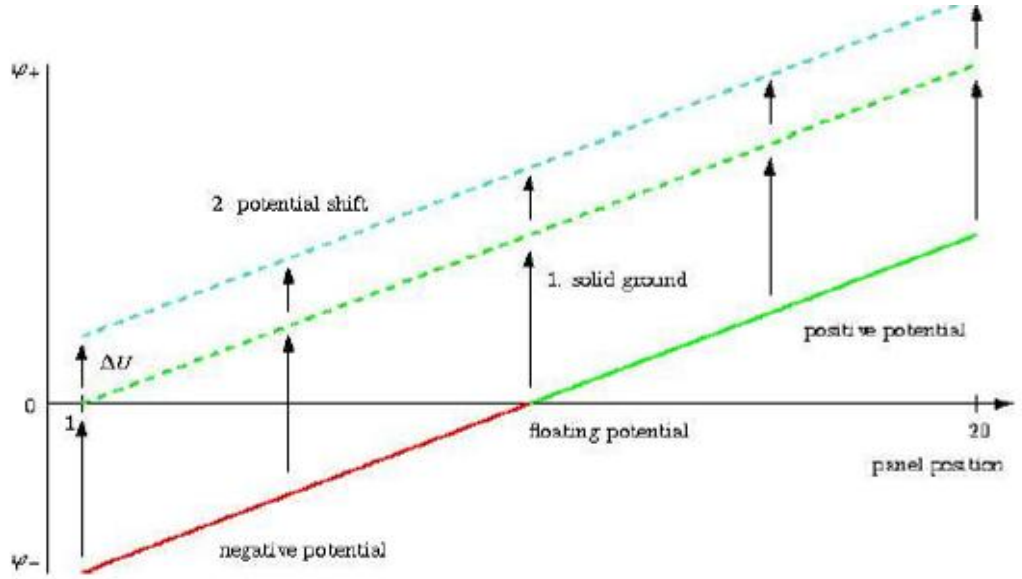
3 IV curve analysis in the field

**Graphik**

- Only measure to really find out the power degradation value
- Less accurate than in the lab

# Preventive Measure Against PID

Conceptual approach: PID only appears if the electrical potential of the panel is negative to ground → push the entire electrical potential of the string to > 0V.



# Preventive Measure Against PID

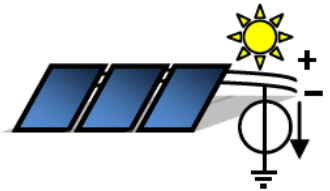
Conceptual approach: PID only appears if the electrical potential of the panel is negative to ground → push the entire electrical potential of the string to > 0V.

If PID is detected at site, there are three different ways to stop PID and even recover the modules.

1. Grounding the negative pole downstream of the inverter

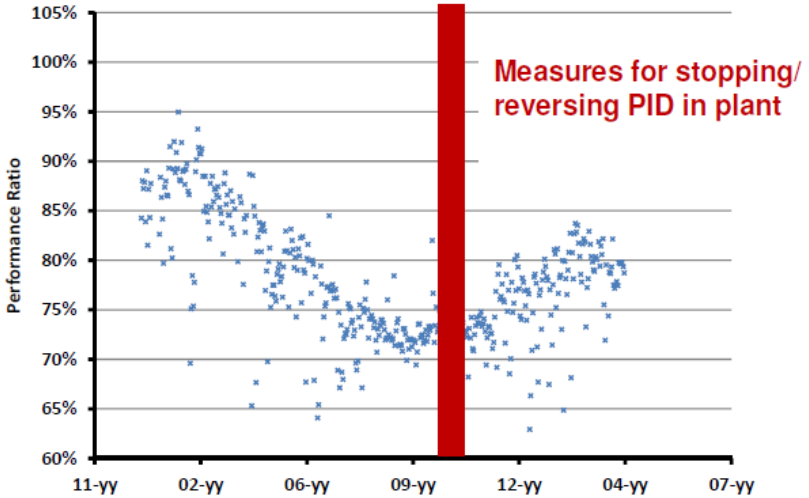

2. Application of positive potential during the night


3. Potential shift during daily operation



# Grounding

By grounding of the negative pole of the module string, no panel will ever face a negative potential towards ground.




*Graph: the performance ratio of the PID-affected power plant during degradation and after grounding of the string.*

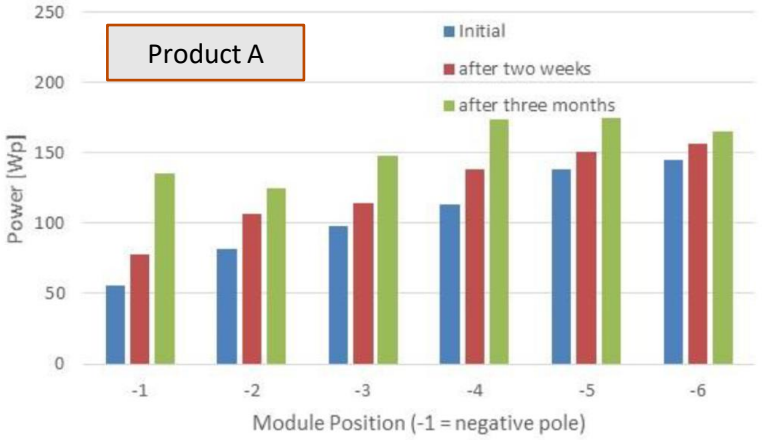
**The simple „trick“ of grounding the negative pole of the module string has been proven to be a very effective measure against PID.**

- For new power plants it prevents from any risk of PID degradation – no matter how PID-sensitive the panel is
- For PID affected power plants it leads to a regeneration of module power. However, it may not provide full recovery and it takes time

# Anti-PI Devices

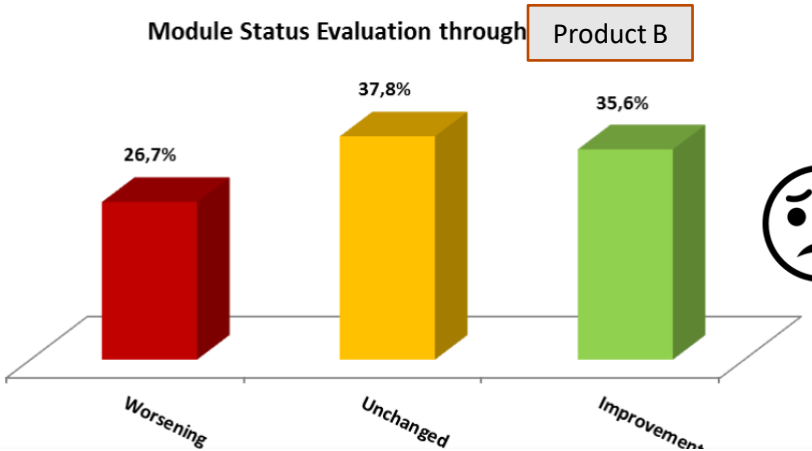
Several of such devices are commercially available. PI-Berlin has tested some of such devices according to their effectiveness on regeneration of PID-affected panels.

1




Summarizing it can be stated that the [redacted] device is working within its specifications. Especially, it should be used for PV-plants slightly affected by Potential Induced Degradation (PID) and plants with PID-sensitive modules in order to stop and to prevent the occurrence of PID. The regeneration of hard affected modules is possible, but will need more time.

2

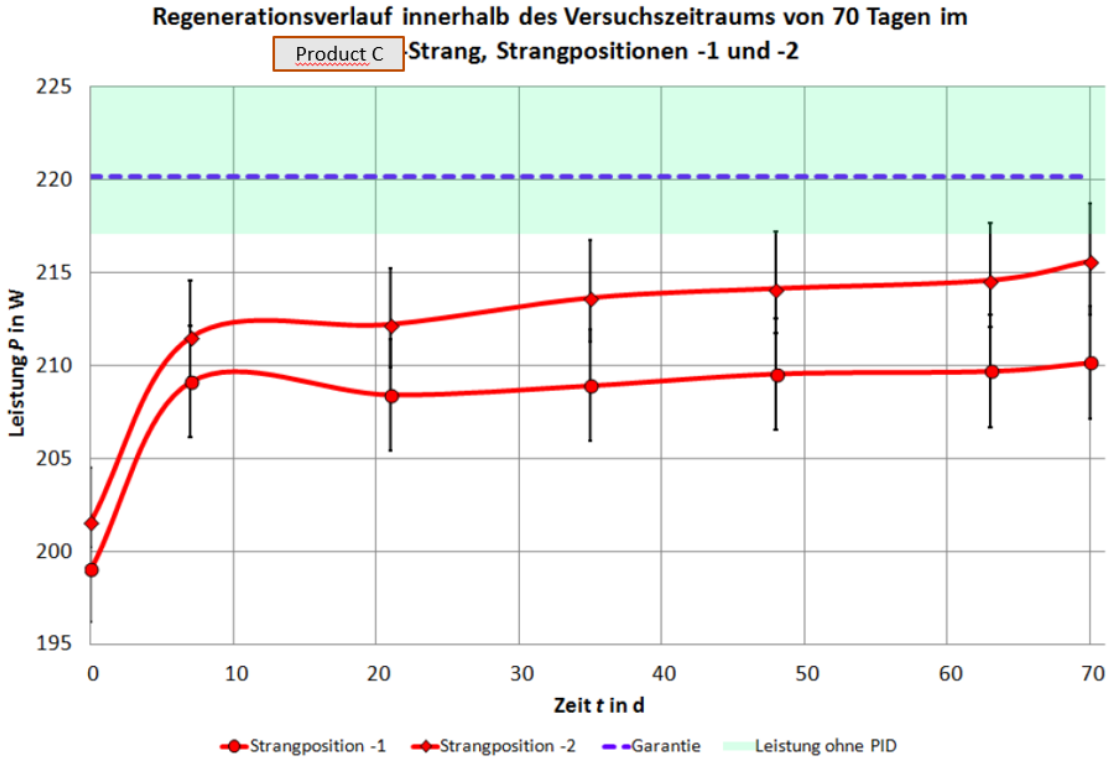



As a consequence althought the percentage of modules with very high power diviations (>20%) has significantly decreased from August 2015 until September 2016, the total percentage of modules beyond the acceptable power limit (>11%) has even increased.

In general, **about half of the analysed modules still show signs of PID.** Therfore **a complete recovery cannot be confirmed yet**. Acc. to IR approx. 17% of all the modules in the PV Plant still show atypical PID pattern. (Note that before the [redacted] installation, it was approx. 35%).

# Preventive Measure Against PID

No matter if grounding or anti-PID devices, the usual regeration pattern is a very quick initial improvement followed by a long and slow regeneration mechanism.



# Summary

**Main driver for PID sensitivity of PV modules is leakage current which strongly depends on**

- Module BOM (cells; encapsulation material, glass, frame)
- Climatic factors: temperature, humidity, dust/soiling situation, solar intensity

Most severe conditions for PID: hot, humid, dusty, high ratio of diffuse light → Chennai

Safer conditions with respect to PID: cold, dry, clean environment, sunny → Atacama desert

**PID can be detected in the field by**

- IR scan (cheap; fast; provides quick overview)
- EL (better accuracy; slow; more expensive)
- IV curve for power loss analysis

**PID can be avoided / fixed by respective measures on the PV power plant design:**

- Grounding of negative pole of the string
- Usage of anti-PID devices
  - 100% safe measure for new power plants
  - Effectiveness on regeneration of PID-affected power plants depends on degradation of panels and type of device

**Latest R&D results:**

**PID sensitivity can change over time. Therefor we always recommend preventive measures for power plants.**

# ANNEX: How „PID-safe“ is a „PID-safe certified“ Panel really?

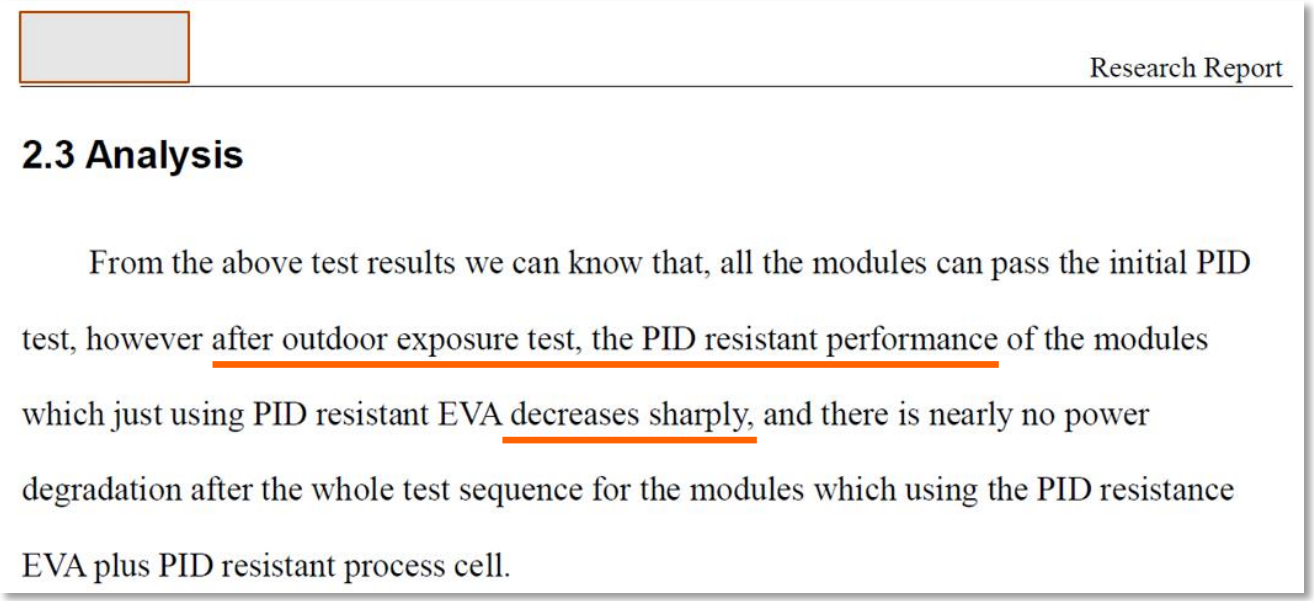
PID-R = PID resistant

| Module Information | | | Test Sequence | | |
|---|---|---|---|---|---|
| SN | EVA | Cell | 60/85PID | Exposure<br>3 months outdoor | 60/85PID |
| A1 | PID-R | PID-R | -0.52% | -0.95% | -1.70% |
| A2 | PID-R | PID-R | | -0.63% | -1.80% |
| B1 | PID-R | Normal | -1.35% | -1.40% | -26.18% |
| B2 | PID-R | Normal | | -1.12% | -18.46% |

*Panel B1 has been certified as „PID-safe“ but after only 3 months of outdoor exposure it becomes sensitive to PID.*

**All data from an internal R&D report from a „Tier-1“ module manufacturer.**

# ANNEX: How „PID-safe“ is a „PID-safe certified“ Panel really?

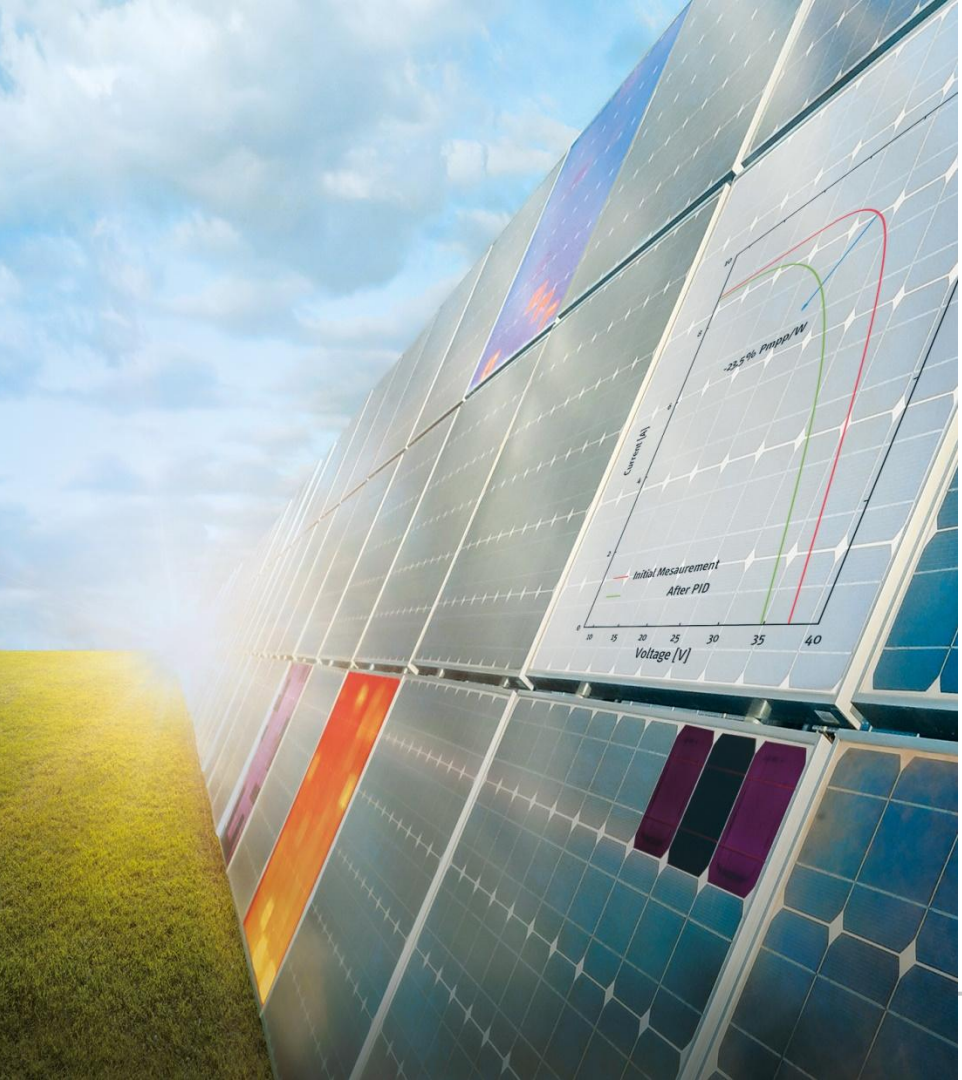


Research Report

## 2.3 Analysis

From the above test results we can know that, all the modules can pass the initial PID test, however after outdoor exposure test, the PID resistant performance of the modules which just using PID resistant EVA decreases sharply, and there is nearly no power degradation after the whole test sequence for the modules which using the PID resistance EVA plus PID resistant process cell.

**All data from an internal R&D report from a „Tier-1“ module manufacturer.**

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