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Reliability of FPV

Stefan Wieland, Fraunhofer Institute for Solar Energy Systems ISE

EUPVSEC Parallel Event 2024

Our vocabulary

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- physical, chemical or mechanical stress acting on PV plant

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Failure:

- *abrupt* change in vital PV plant metrics, can also be cascading/catastrophic

Our aim

- to identify FPV-specific
  - stressors
  - affected components
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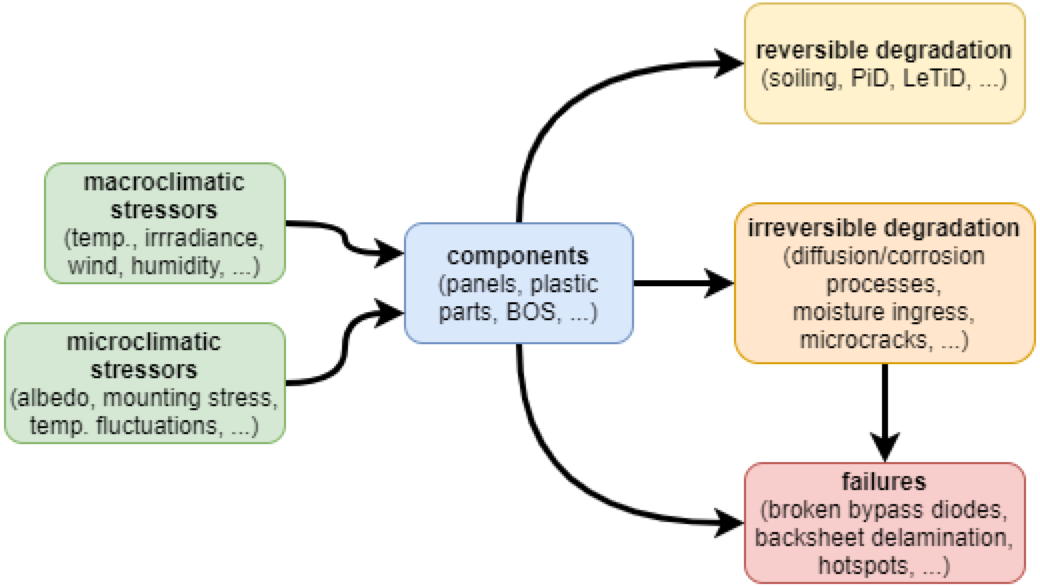

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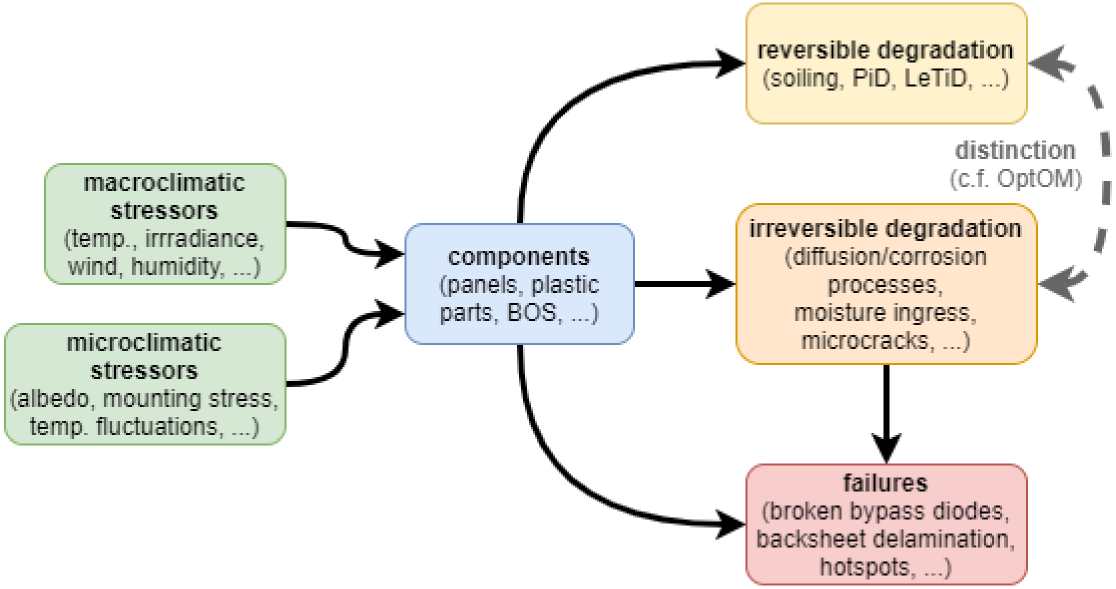

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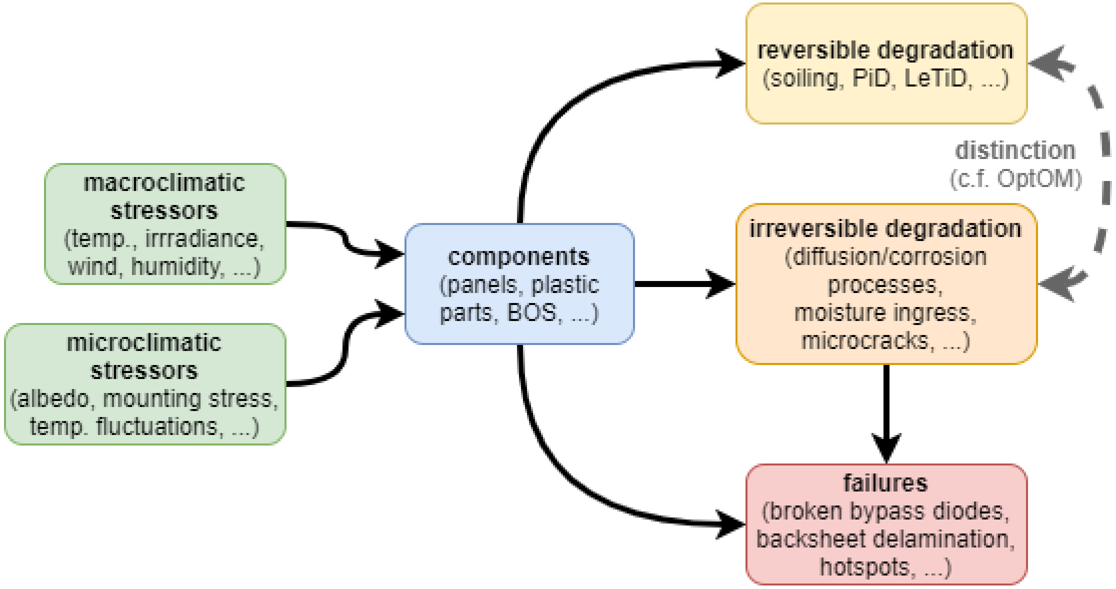

- to map interdependencies

- to quantify degradation (onsite data, lab tests, simulations)

FPV stress profiles: Differences to GPV

- increased **mechanical loads** on more **complex mechanical support**

  ➡ increased **fatigue** and compromised **mechanical integrity**

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- higher **humidity** and **water exposure**

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- lower **operating temperature**

  → less thermally-activated **degradation**

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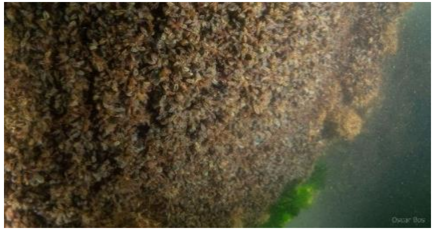
  - ➡ enhanced **corrosion**
  - ➡ increased **tear** through mechanical removal



Mavraki et al. 2023

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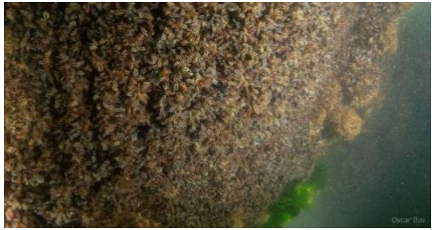

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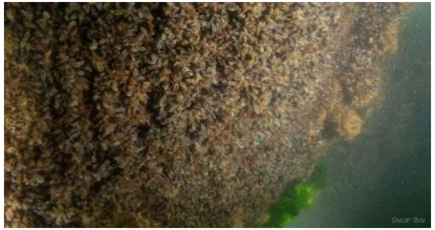

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  - ➡ **hotspot** formation

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  - ➢ varying water exposure
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© Ciel & Terre
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- **Dependent on waterbody type**

© EDP

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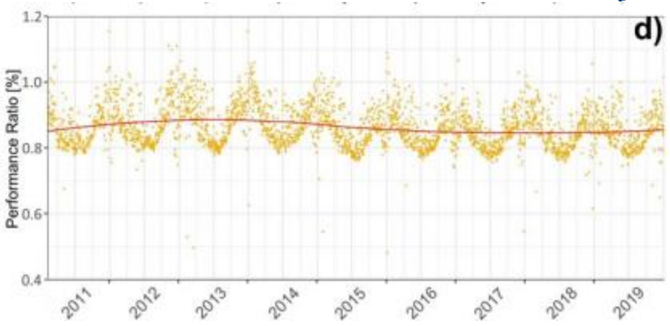
Quantifying degradation: *Basics*

- **through performance loss rate (PLR)**
  - ➢temporal decline of power output
  - ➢essential ingredient in economic analysis



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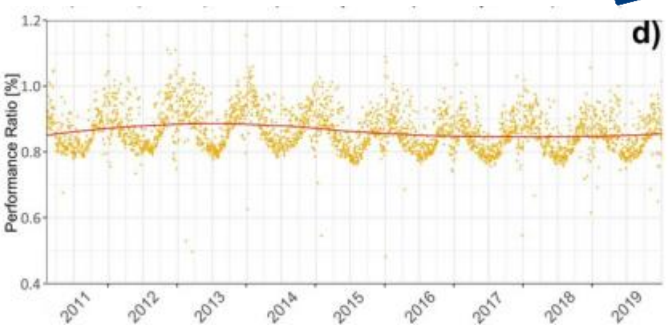
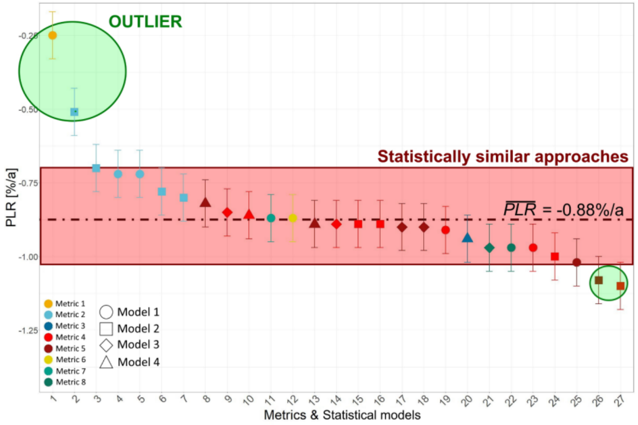


- **with several methods**
  - ➢ordinary least squares
  - ➢seasonal-trend decomposition using LOESS
  - ➢year-on-year



Sascha Lindig et al. 2022 Prog. Energy 4 022003

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Quantifying degradation I: *PLRs from onsite data*

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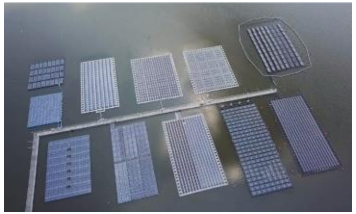
(Multi-/Mono-Si; same for roof PV)



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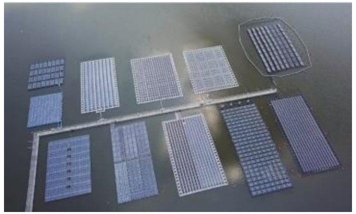

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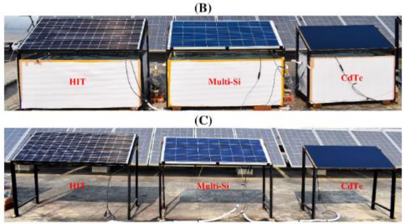

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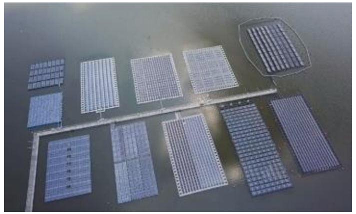

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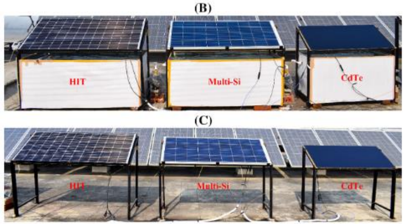

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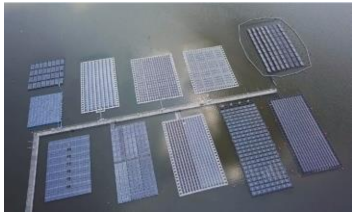

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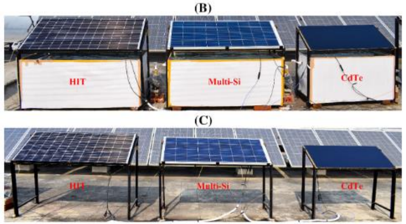

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  - **IEC 62782** (dynamic mechanical loads)
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- **on floating structure:**
  - ➢ wind flow non-trivial; couple CFD with tool modelling …
  - ➢ … hydrodynamics, flexibility (Nygaard et al. 2016, Ikhennicheu et al. 2022)
  - ➢ but account for feedback loop to stress levels in module interior

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(4) Thermally induced stresses

- coupled thermal and mechanical FEM simulations to compute fracture probability of module glass (Beinert et al. 2023)

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- **We want:** measurement/quantitative prediction of PLRs and failure frequencies.

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