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Service life model for PV-modules

Model to predict the service lifetime of PV-modules in moderate climates

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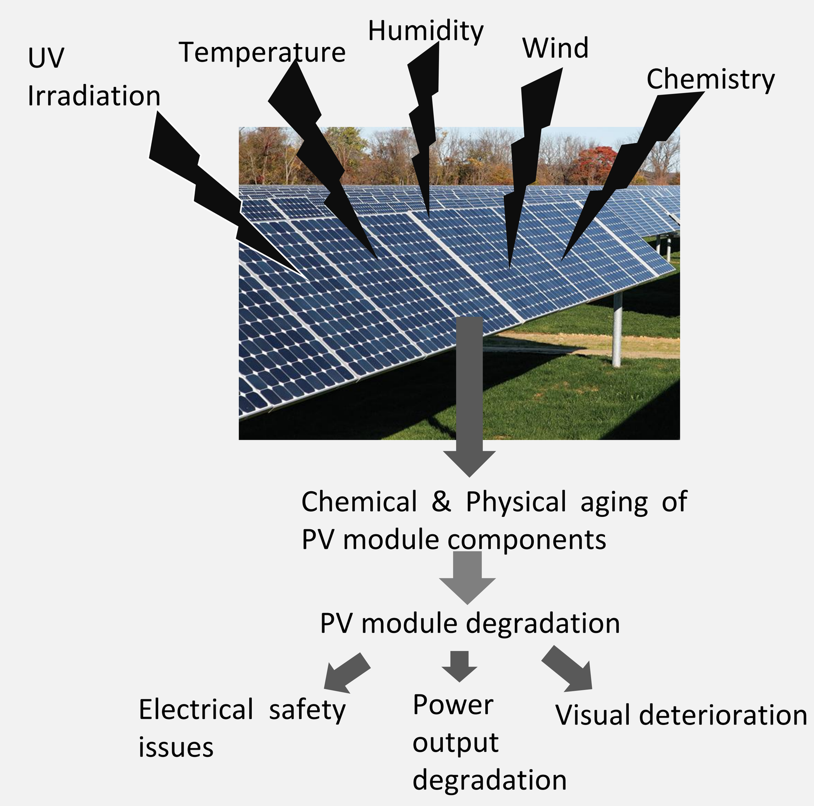
MOTIVATION


Outdoor mult-c-Si Module showing yellowing and mettalization corrosion. (N.kahoul et al, renene 2017)

- More and more photovoltaic modules are being installed throughout the world, however less is known about their reliability.
- Understanding the performance degradation of photovoltaic modules is critical for optimizing it's financial viability and ensuring electrical safety throughout a module's service life is essential.
- There is a need to develop a valid service life and perfomance degradation model to estimate the reliability of PV modules taking into consideration the different climatic conditions.

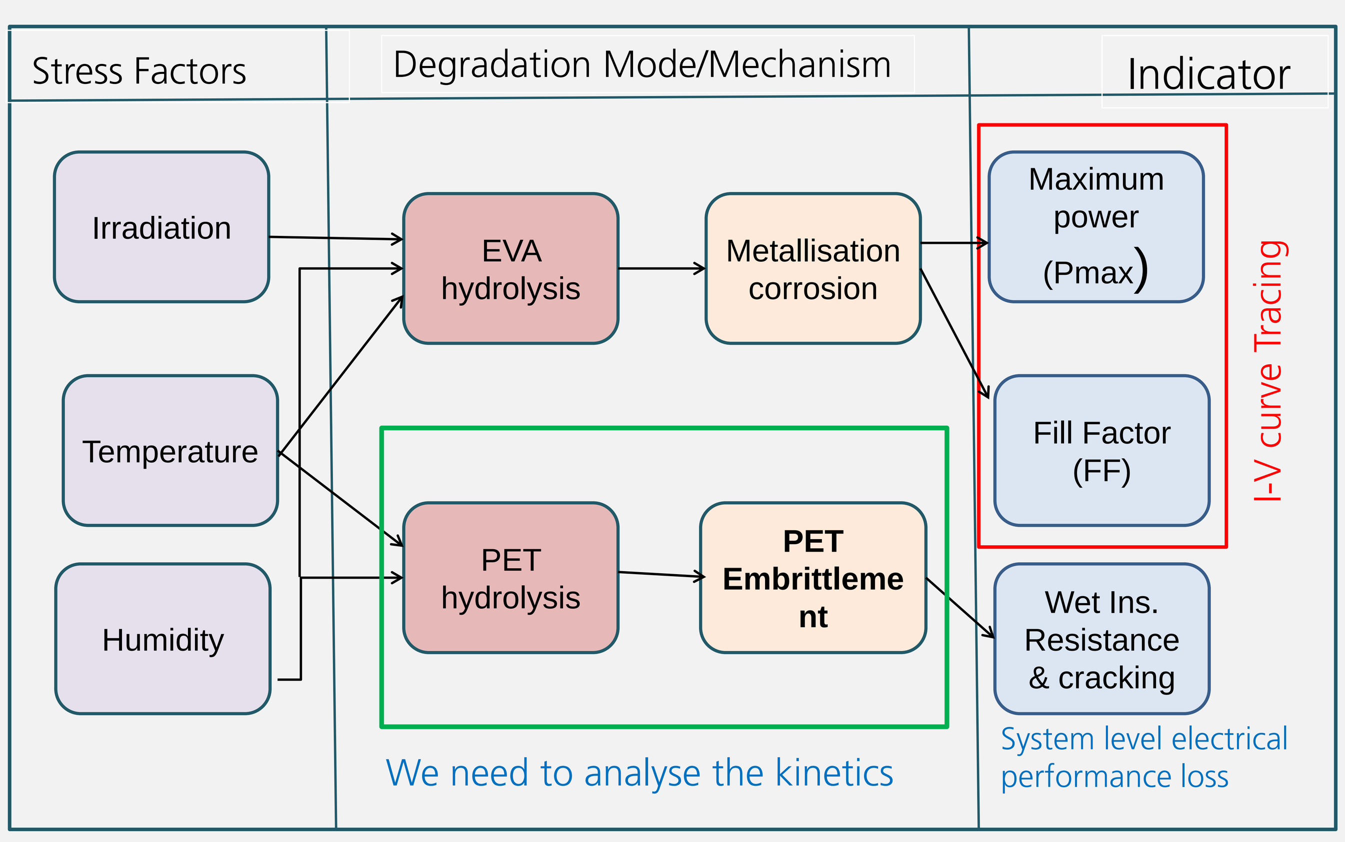
OPEN QUESTIONS



- What are the most common degradation modes in PV modules?
- What are the impacts of both internal and external stress factors on PV module components' degradation?
- How to predict the service lifetime of PV-modules using mathematical models and numeric simulations, taking into account both material degradation and micro-climate loads?

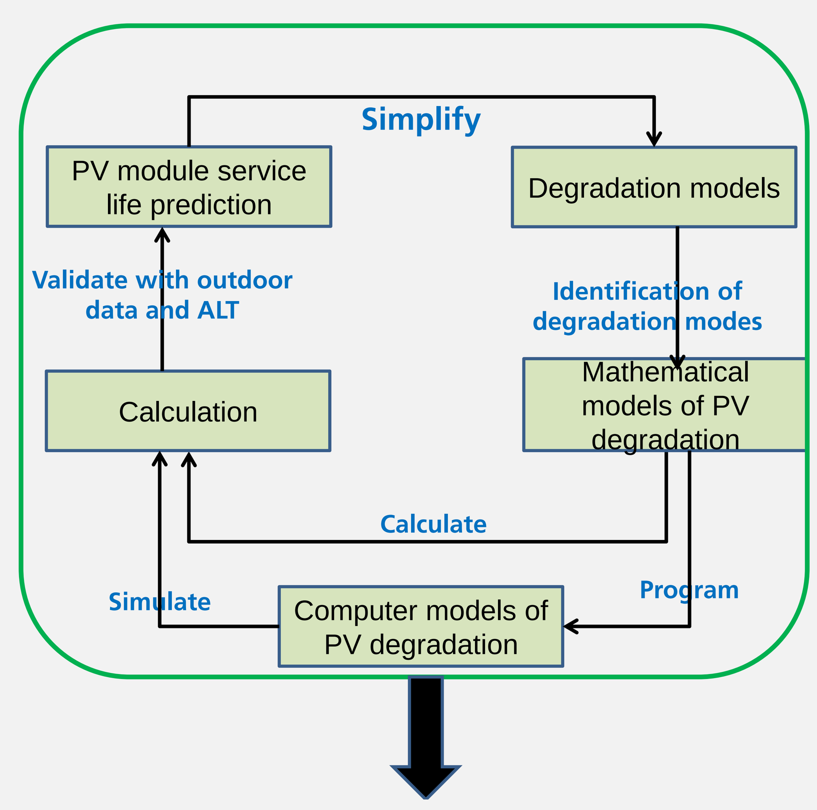
PV MODULE DEGRADATION

- Here degradation is defined as the gradual decrease in the output power over time.
- In literature[1,2], the most common c-Si PV module degradation modes include:
  - Corrosion, Encapsulant discoloration , Cell breaking, Solder bond failures and Interconnects cracking .
- These modes are due to the influence of:
  - Temperature, humidity, UV irradiation, wind/snow loads and different thermal expansion/coefficients.



1. A. Charki et al, ," Accelerated degradation testing of a PV module' , Paper 12017SSP, 2013.
2. C.R. Osterwald and T.J. McMahon, ,"History of accelerated and qualification testing of terrestrial photovoltaic modules.'a literature review." prog. Photovoltaic.

METHODS



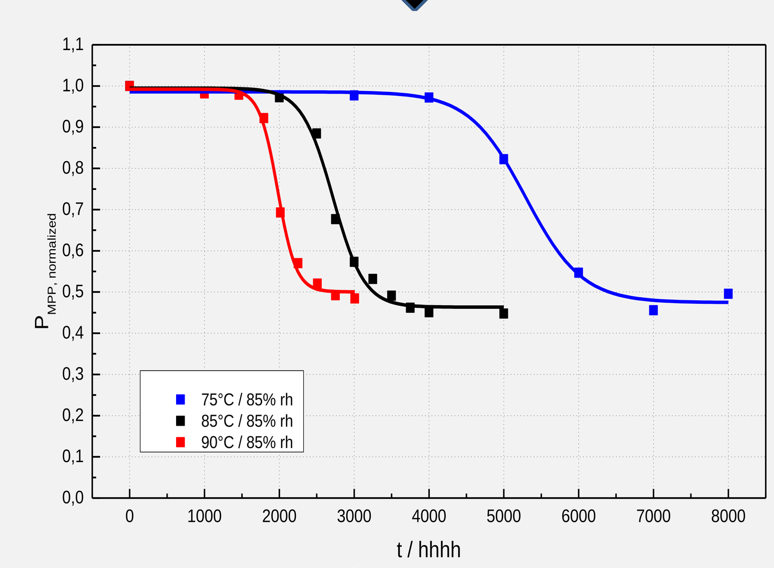


Figure showing time of failure from accelerated tests (Michael Köhl, Karl-Anders Weiß)

Modeling transport phenonmenon

- Calculation and numerical simulation of relavant transport phenomenon in PV module and quantification of specific impacts of various external and internal stresses such as temperature, UV irradiation, relative humidity, on specific module components such as encapsulation, metallization, backsheet.

Micro-climate model

- Finding a micro-climnate model for module degradation on the basis of collected climatic data and PV module perfomance data.

Service life prediction model

- Formulate material degradation and micro-climate models in an integrated model for PV module service lifetime prediction.

WP1 MODELING DEGRADATION MODES KINETICS

- Identification of relevant dominating or common degradation modes in PV module.
- Identification of stress factors leading to specific degradation mechanisms and on specific module components.
- Identification of related mathematical models and simulations to reproduce the common degradation modes.
- Validate and analyse the models with accelarated tests or outdoor data available.

WP2 MICRO-CLIMATE MODELING

- Here we define microclimates as the in-service environment of polymeric materials contained within the PV module.
- The influence of the microclimate on the aging behavior of polymeric materials on the optical, chemical and morphological properties of the materials will be studied.
- Correlation of the microclimate model with accelerated aging test results.

WP3 SERVICE LIFE MODEL VALIDATION

- Combine both material degradation model and micro-climate model into a single model for service lifetime prediction.
- Validate the model with outdoor data and accellerated aging tests.
- Test the model with c-Si PV module technology and correlate it with oudoor performance.

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