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PV MODULE LIFE TIME FORECAST AND EVALUATION

Service Lifetime Prediction of PV Modules and Systems: Progress of the SOLAR-TRAIN Project

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INTRODUCTION

The project SOLAR-TRAIN aims to develop novel and validated models for the service life time and energy yield prediction of PV modules and systems. PV modules' & systems' performances are being investigated along the entire modelling chain: climatic degradation factors, analysis of degradation and failure modes and evaluation of polymeric materials. This work presents an overview of the current start-of-the-art and some preliminary results on the development of service lifetime prediction models for PV modules & systems.

DEGRADATION RATE EVALUATION OF A PV SYSTEM

Poly-crystalline Si system:

- Nominal power: 4.2kWp
- Parameter: P_{MPP}; I_{MPP}; V_{MPP}
- In operation since 2011

Weather station:

- Temperature
  - Ambient & module
- Irradiance
  - Plane of array, global horizontal & diffuse

Fig. 1 Studied PV system located in Bolzano (North of Italy).

BASED ON PREVIOUS STUDIES

Comparison of statistical methods to calculate Performance Loss Rates [1]

5 different statistical models for the calculation of Performance Loss Rates (PLR) were investigated on different PV systems & technologies. Seasonal & trend decomposition using LOESS (STL) as well as auto-regressive integrated moving average (ARIMA) where found to have the lowest uncertainities and consistent final values.

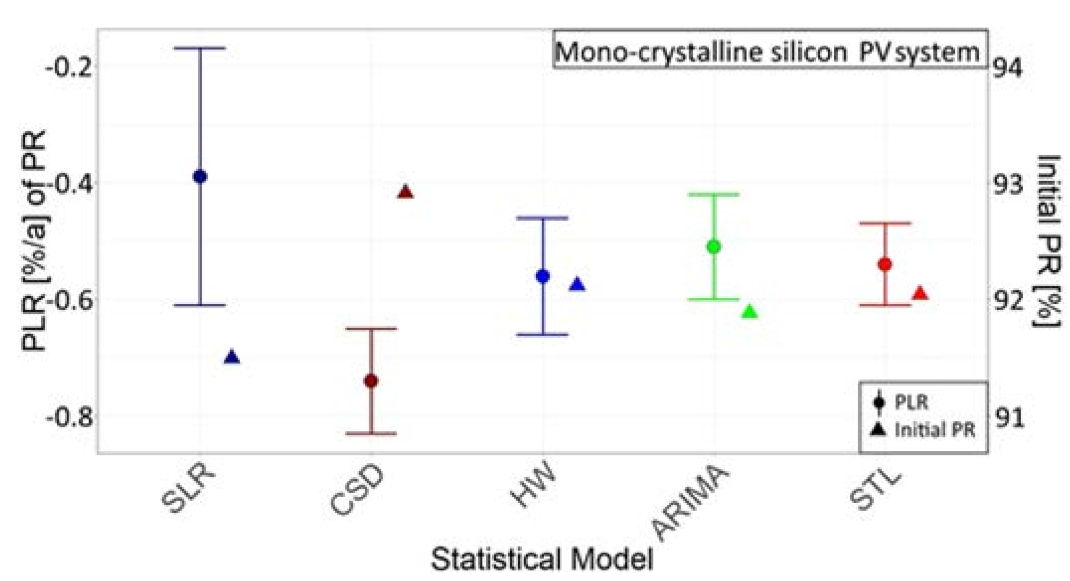
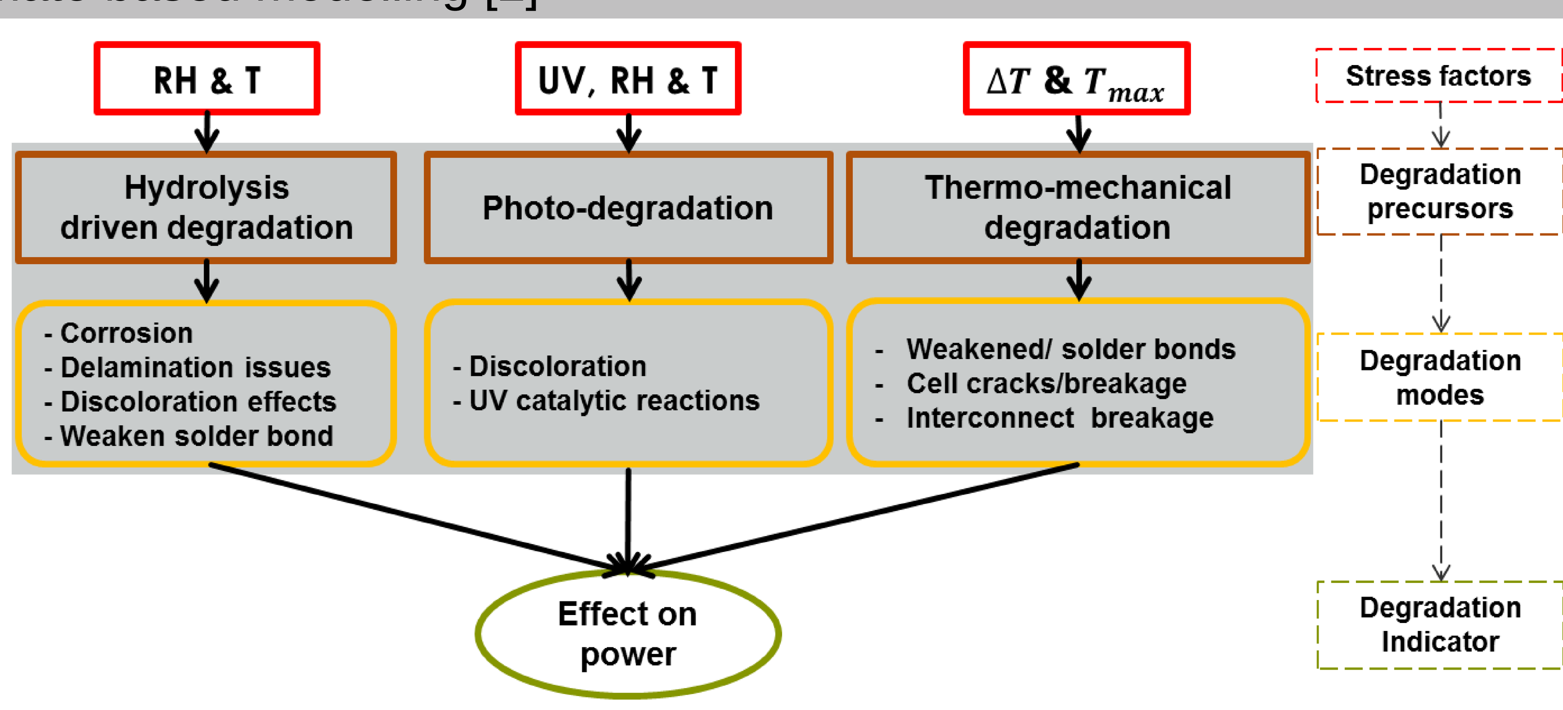


Fig. 2 Comparison of statistical models on PR-data of mc-Si system, circles represent PLR (primary axis), triangles represent initial PR.

Climate based modelling [2]



A **total degradation rate** (k_T) was proposed assuming 3 degradation precursors:

Hydrolysis ($\boldsymbol{k_h}$); Photo-degradation ($\boldsymbol{k_p}$); Thermo-mechanical ($\boldsymbol{k_{Tm}}$)

$$k_T = (1 + \boldsymbol{k_h}(T, RH)) * \left(1 + \boldsymbol{k_p}(UV, T, RH)\right) * (1 + \boldsymbol{k_{Tm}}(\Delta T, T_{max})) - 1$$

EFFECT OF FILTERING ON PLR EVALUATION

Filter	Irradiance	Other		$\widetilde{PR} \pm \sigma$	% Filtered
Positive Values	Remove NA & negative	Remove NA & neg Power		0.825 ±0.141	55.28%
Clear sky instants		0.75 < P/G < 1.25		0.845 ±0.071	65.3%
PR statistical	500 < G < 1200	$0.1 * P_{nom} < P_{DC} < 1.2 * P_{nom}$	PR_{mode}: ±2σ	0.850 ±0.049	83.4%

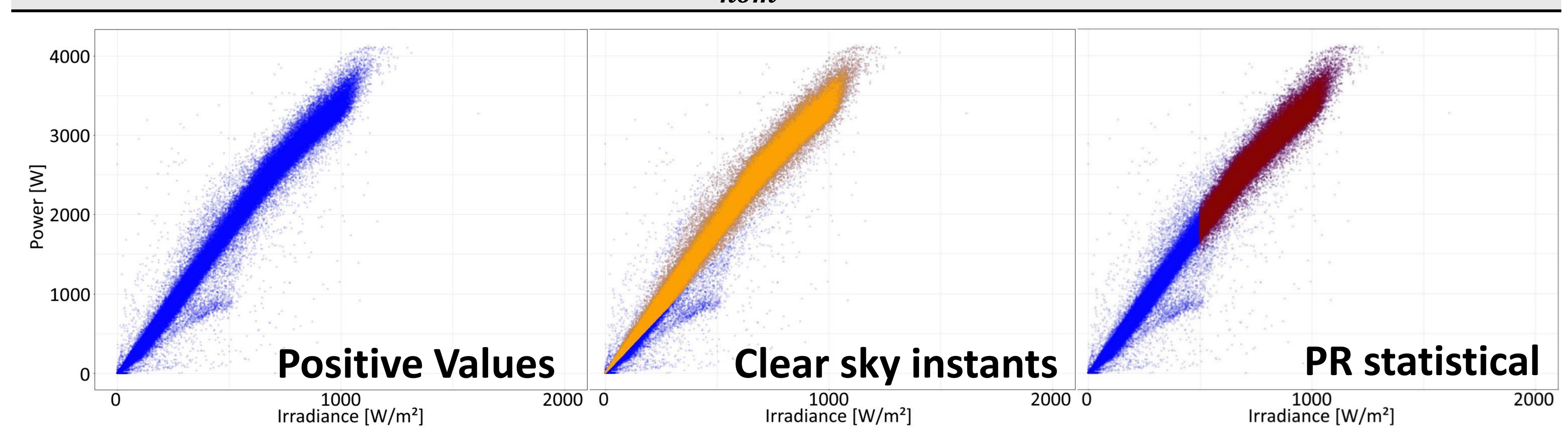


Fig. 3 Power against irradiance of investigated pc-Si system for 3 different filters tested.

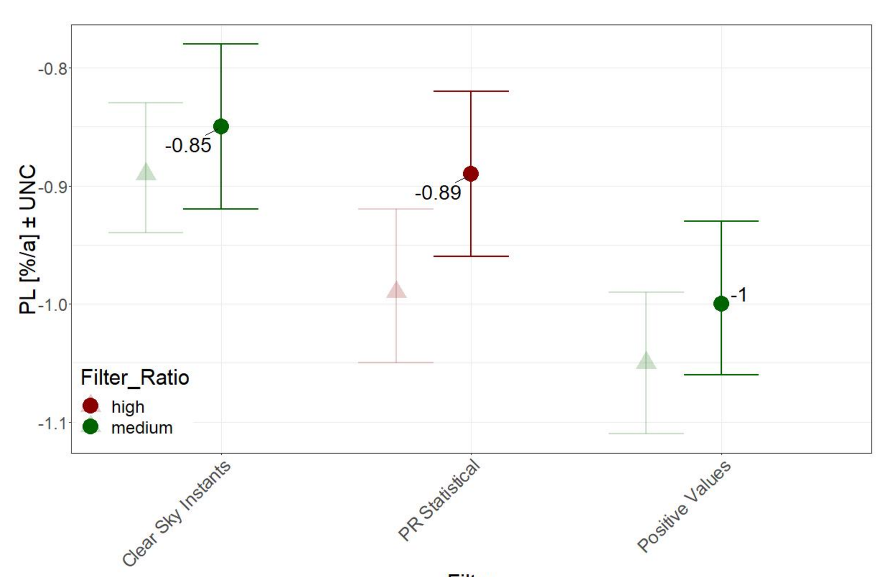


Fig. 4 PLR including related uncertainties (circle: T-corrected PR; triangle: PR).

PLR is between -0.8%/a to -0.9%/a while a degradation rate of -0.45%/a has been calculated considering climate effects only. The deviation between both values can be attributed to technical failures, which are not classified as a physical degradation of the system (e.g. soiling, shading, …).

Climate based modelling:

Rate	k_h	k_p	k_{Tm}	k_T
Value	-0.030%/a	-0.080%/a	-0.301%/a	**-0.45%/a**

YIELD ASSESSMENT ACCURACY [3]

- Filter: physically possible (extremely rare) limits & theoretical sun path
- Clear sky days identification based on correlation with clear sky model (Perez)
- Uncertainty evaluation (JCGM 100:2008) from interpolated values based on calibration

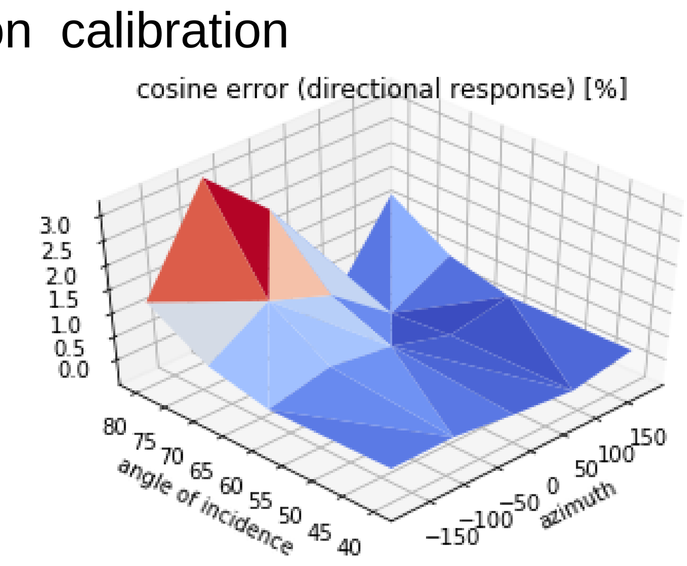


Fig. 5 Interpolation of cosine error of pyranometer based on response values extracted from the calibration certificate.

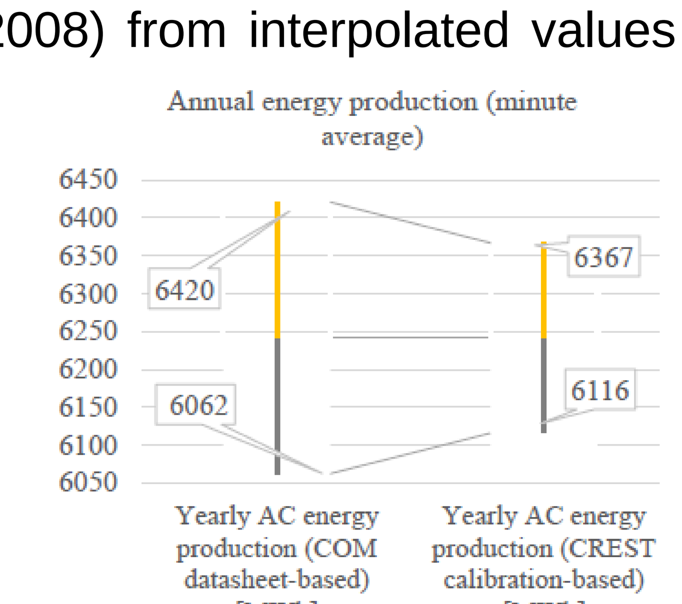


Fig. 6 Decrease of energy production uncertainty with help of calibration information in a 7389 kWp solar farm.

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This project has received funding from the European Union's Horizon 2020 research programme under the Marie Sklodowska-Curie grant agreement No 721452.