PV MODULE LIFE TIME FORECAST AND EVALUATION

Multi-Step Performance Loss Rates of Photovoltaic Systems

S. Lindig[1,2], D. Moser[1], M. Topič[2]
[1]EURAC Research – Institute for Renewable Energy / Viale Druso 1, 39100 Bolzano, Italy / +39 0471 055 715 / sascha.lindig@eurac.edu
[2]University of Ljubljana / Tržaška cesta 25, 1000 Ljubljana, Slovenia

INTRODUCTION

Photovoltaic (PV) performance and the study of its decrease over time has received an increasing amount of interest within the past years. Usually, the performance loss (PL) is assumed to be linear. A fundamental question is if a linear PL is actually realistic. When studying the trend of PV systems closely a non-linear performance trend evolution is usually detected, e.g. thin-film systems often experience a stabilization phase in which the PL is enhanced for a limited amount of time. In order to evaluate the PL of PV systems in greater detail multi-step performance losses, divided by breakpoints, might be an interesting solution. By dividing the performance evolution into multiple PL we expect to better understand what happens to a PV system in the field to gain more information about the appearance of degradation modes in PV systems modules, and to provide a better tool for the evaluation of warranty claims.

PV SYSTEMS

PV plant
- 12 systems
- 2 technologies
- In operation since FEB-11
- Tilt: 30°
- Azimuth: 188.5° (SSW)
- Temperate climate (KG)
- Mounting: free standing

Weather station
- Plane-of-array irradiance
- Ambient temperature
- Module temperature

Fig. 1. Meteo station

Fig. 2. PV systems

CALCULATION STEPS

Filter
- Irradiance: 500-1200W/m²
- Monthly PR mode: ±2σ

Correction & Normalization
- PR correction for T_{mod} (IEC 61725-1)
- Aggregate to monthly values

PL calculation
- STL[1] to extract performance trend
- Multi-step regression[2,3] of STL trend → 3-step PL

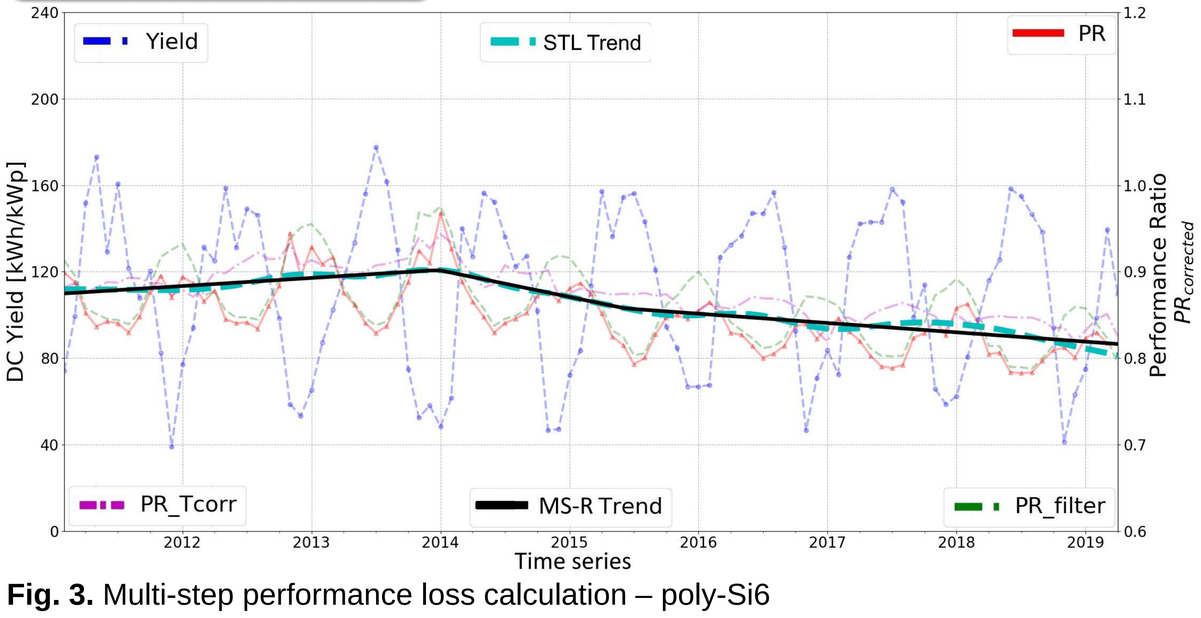

Fig. 3. Multi-step performance loss calculation – poly-Si6

RESULTS

Tab.1. Multi-step PL values for poly- (pc) and mono-crystalline (mc) PV systems

	pc-Si1	pc-Si2	pc-Si3	pc-Si4	pc-Si5	pc-Si6
PL_{linear}	**-1.48%/a**	**-0.70%/a**	**-1.08%/a**	**-0.92%/a**	**-1.03%/a**	**-0.59%/a**
UNC	±0.09%	±0.05%	±0.07%	±0.07%	±0.06%	±0.06%
PL_{seg1}	**0.85%/a**	**1.29%/a**	**0.95%/a**	**1.42%/a**	**1.27%/a**	**1.70%/a**
	Feb11 - Aug13	Feb11 - Oct13	Feb11 - Nov13	Feb11 - Nov13	Feb11 - Nov13	Feb11 – Oct13
PL_{seg2}	**-4.15%/a**	-2.63%/a	**-3.66%/a**	-3.05%/a	-3.09%/a	-2.72%/a
	Aug13 - Feb16	Oct13 - Sep15	Nov13 - Nov15	Nov13 - Sep15	Nov13 - Sep15	Oct-13 - Jul-15
PL_{seg3}	**0.38%/a**	**-0.35%/a**	**-0.14%/a**	**-0.81%/a**	**-0.90%/a**	**-0.42%/a**
	Feb16 - Apr19	Sep15 - Apr19	Nov15 - Apr19	Sep15 - Apr19	Sep15 - Apr19	Jul15 - Apr19

	pc-Si7	mc-Si1	mc-Si2	mc-Si3	mc-Si4	mc-Si5
PL_{linear}	**-0.85%/a**	**-0.32%/a**	**-0.25%/a**	**-0.95%/a**	**-0.76%/a**	**-0.81%/a**
UNC	±0.06%/a	±0.06%/a	±0.05%/a	±0.07%/a	±0.12%/a	±0.07%/a
PL_{seg1}	**1.37%/a**	**2.07%/a**	**1.52%/a**	**1.52%/a**	**3.24%/a**	**1.36%/a**
	Feb11 - Nov13	Feb11 - Aug13	Feb11 - Nov13	Feb11 - Jan14	Feb11 - Oct13	Feb11 - Dec13
PL_{seg2}	-2.75%/a	**-2.02%/a**	-2.09%/a	-4.48%/a	**-3.06%/a**	**-3.01%/a**
	Nov13 - Jun15	Aug13 - Dec15	Nov13 - Sep15	Jan14 - Aug14	Oct13 - Mar16	Dec13 - Feb16
PL_{seg3}	**-0.93%/a**	**0.13%/a**	**0.10%/a**	**-1.55%/a**	**-0.74%/a**	**-0.05%/a**
	Jun15 - Apr19	Dec15 - Apr19	Sep15 - Apr19	Aug14 - Apr19	Mar16 - Apr19	Feb16 - Apr19

- Linear PL: all systems are subject to an overall performance loss
- Through multi-step performance loss consideration the performance evolution is described in greater detail and can be better understood
- Investigated systems experience performance gain at the beginning of their lifetime
  - ➢ Possibly the observed performance improvements are due to prevailing weather conditions
- Afterwards, most systems are subject to a strong performance decrease followed by a lowered loss or in some cases even slight gain

OUTLOOK

Improve algorithm and study results in greater detail
- Adapt calculation algorithm without specifying number of breakpoints
- Evaluate results in greater detail by dividing overall performance effects (losses/gains) into physical degradation of the PV system in question and other performance changing effects
- Study physical degradation by evaluating MPP current evolution and by performing on-site visits
- Extend to thin-film systems

REFERENCES

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STL – Seasonal & Trend Decomposition using Loess

https://solar-train.eu/ @MSCA_SolarTrain

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