Power trend assessment of a large worldwide PV dataset

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A worldwide portfolio composed by 289 PV plants, with a total installed capacity of more than 3 GW_{DC} has been analyzed, showing a median power trend of -0.5%/year.

Introduction and Data

Degradation rates are essential for evaluating the long-term performance and economic viability of photovoltaic (PV) plants. The primary objective of this study is to determine the most representative value for system power trend by analyzing a large dataset. To achieve this, the Year-on-Year (YOY) methodology is applied to calculate annual Performance Loss Rates (PLR), implemented using the Python-based RdTools software [1]. Additionally, the study aims to identify and address factors that influence the accuracy of PLR calculations, such as sensor calibration, data filtering and tendency changes.

The dataset used in this study consists of measured weather data — Global Tilted Irradiation (GTI), ambient temperature, and cell temperature — and system's output power of PV plants distributed globally, with a sample frequency of 5-minute interval. **The dataset comprises 289 PV plants with a total installed capacity of 3,041 MW_{DC} and 1,945 years of cumulative data**. The analyzed dataset contains exclusively PV plants with more than 5 years of data and an installed capacity higher than 1 MW_{DC}.

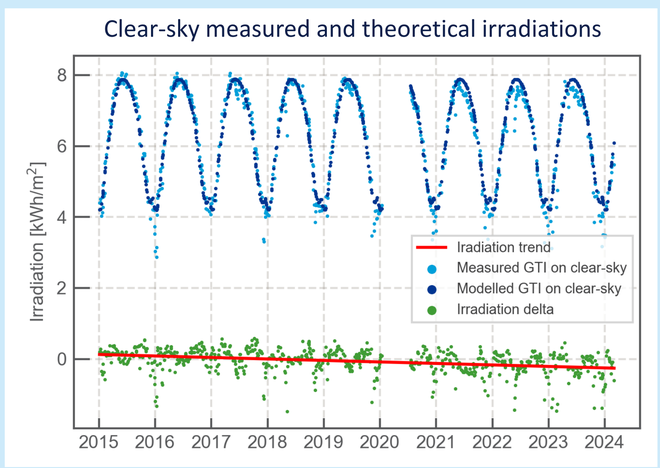
Location	# PV plants	MW_{DC}	cum. yrs	yrs/plant
Europe	221	1,598	1,524.3	6.9
North America	22	582	142.2	6.5
Australia	11	365	61.7	5.6
South America	24	338	148.9	6.2
Asia	10	137	61	6.1
Africa	1	22	6.5	6.5
All dataset	**289**	**3,041**	**1,944.6**	**6.7**

Data validation (IEC 61724-3)

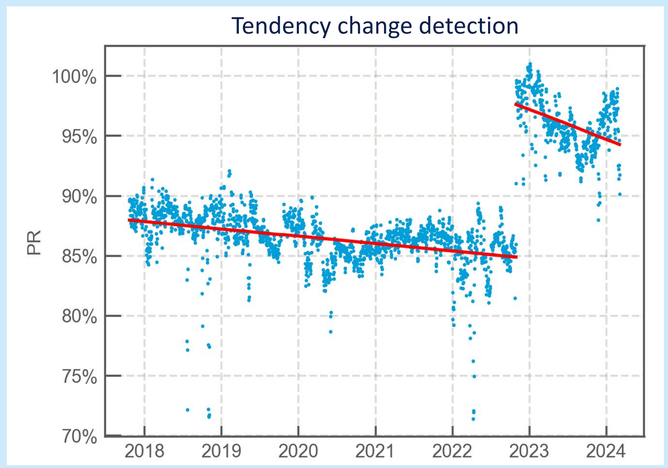
5-min data
Remove duplicated timestamps
Get continuous timestamps
Interpolate small data gaps (<1 hour)
Remove out of bounds data
Remove stuck sensor data (frozen)
Remove abrupt changes in data
Audit sensors (to obtain a single signal)

Data reliability verification

Exclusion of PV plants with non-reliable and degrading irradiation sensors

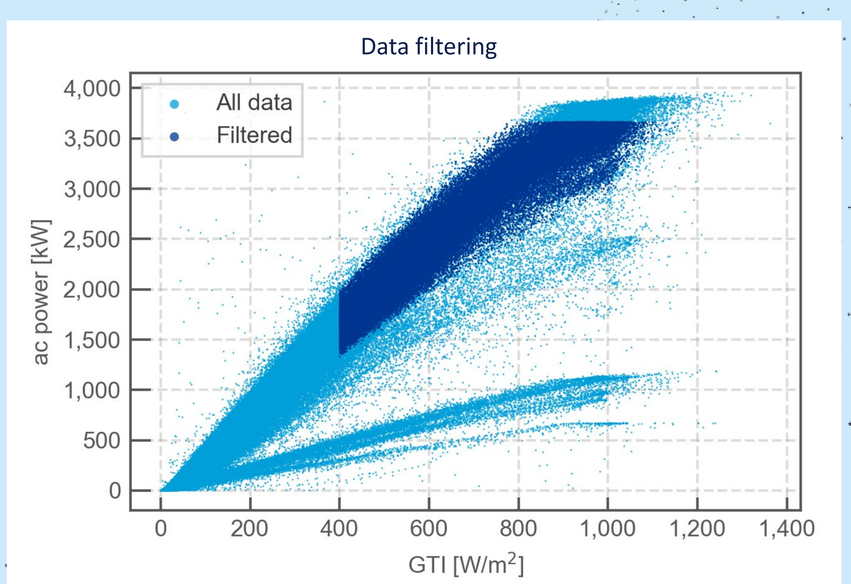


Detection of tendency changes in the data to avoid misleading results.



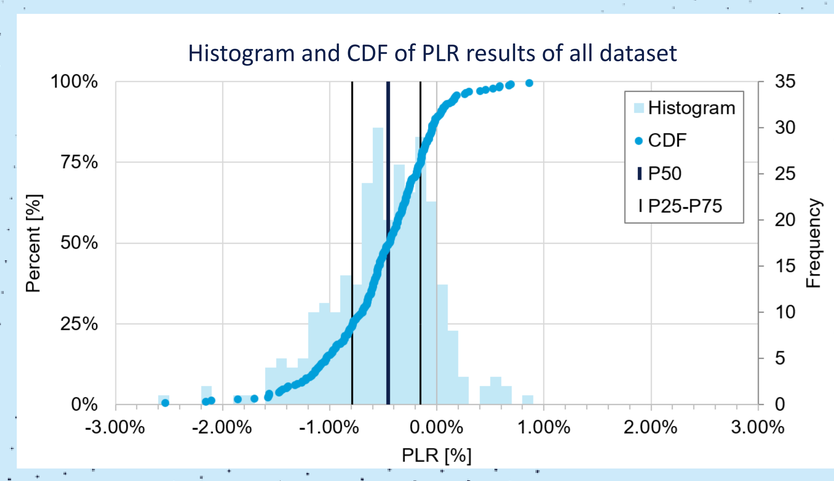
Filtering

1. *Irradiation*: Remove periods with GTI lower than 400 W/m² and higher than 1,200 W/m²[1].
2. *Clipping*: Remove clipping periods by removing the non-linear periods.
3. *Low-performance*: Remove periods with underperformance such as partial outages or curtailments. This filter excludes periods with Performance Ratio (PR) outside of the representative band.



Evaluation of results

The PLRs of all dataset have been calculated, obtaining the following result evaluation.

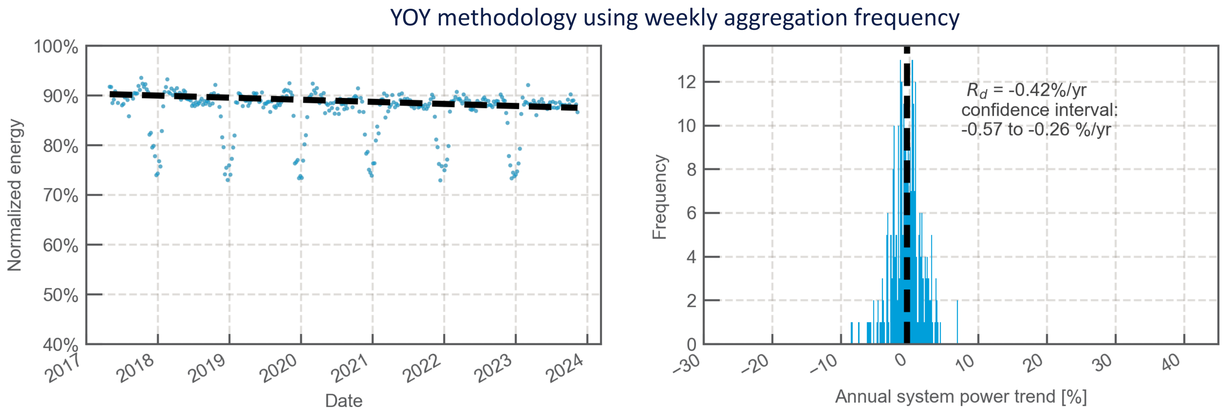


Location	# PV plants	MW_{DC}	P25	P50	P75
Europe	221	1,598	-0.1%	-0.4%	-0.7%
North America	22	582	-0.6%	-1.0%	-1.3%
Australia	11	365	0.2%	-0.5%	-0.8%
South America	24	338	-0.2%	-0.4%	-0.7%
Asia	10	137	-0.4%	-0.6%	-0.8%
Africa	1	22	-	-1.6%	-
All dataset	**289**	**3,041**	**-0.2%**	**-0.5%**	**-0.8%**

Performance Loss Rate calculation

PLR values have been obtained following YOY methodology using RdTools python package. Weekly aggregation frequency has been considered, which has provided coherent results for this study as well as in other case studies [3].

YOY methodology using weekly aggregation frequency



Conclusion

- A detailed workflow of PLR analysis using RdTools has been proposed. Several steps have been improved from the standard methodology [3], such as obtaining data-driven plant parameters and improved filters.
- The portfolio evaluation shows that the **median (P50) PLR value for the whole dataset is -0.5%/year,** with percentiles 25 (P25) and 75 (P75) being -0.2%/year and -0.8%/year respectively.

Poster

Paper

References

[1] M. G. Deceglie et al. *RdTools* Version 2.2.0. Available: https://github.com/NREL/rdtools, DOI: 10.5281/zen-odo.11409981. 2024.
[2] J. Newmiller. *2020 PV Reliability Workshop*. Feb. 2020
[3] D. Jordan et al. *Robust PV Degradation Methodology and Application*. In: IEEE Journal of Photovoltaics 8.2 (2018),pp. 525–531.