Operational Performance of Grid-Connected PV Systems

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Introduction

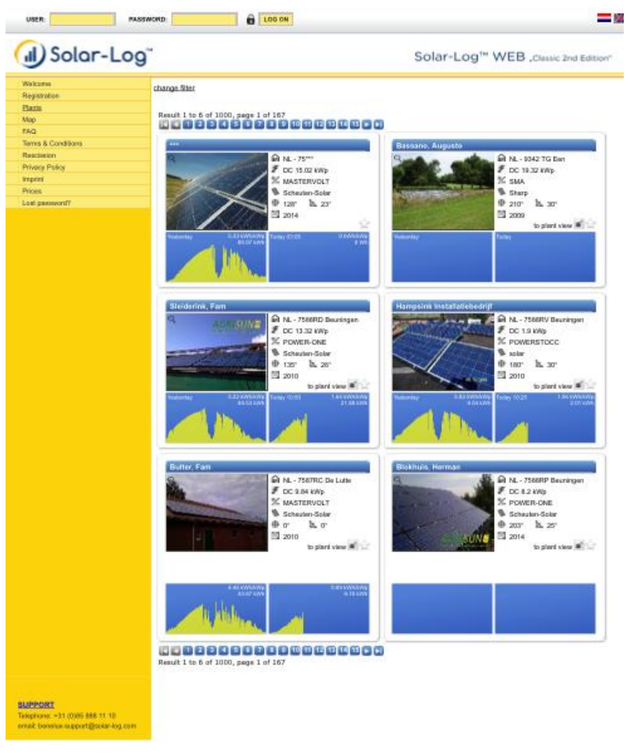
Photovoltaic (PV) technology has become a mainstream energy harvesting option in the renewable portfolio in the coming decades. In residential applications (1-5 kWp in size) monitoring equipment usually is insufficient. Reasons for lower performance than expected (or promised) are therefore difficult to detect.

Monitoring applications that are available on the market today include a number of web tools allowing owners to monitor system performance and the production of their system at any point of the day.

The aim of this paper is to **analyze PV performance data** obtained by **web scraping** techniques that collect and organized these data automatically in databases.

Methodology

Online service of Solar-Log [1] was used as source of data; it offers free access to the users' web platform.



Scripts in Python have been developed that:

- simulated human navigation through web sources (aka 'web scraping')
- located and saved scattered information
- organized that information in database

Daily AC and DC yields were thus obtained in conjunction with PV system details (orientation, tilt, size).

Performance ratio was calculated using

$$PR = \frac{Y_{final}}{Y_{ref}}$$

with Y_{final} the final system yield and Y_{ref} the reference yield [2].

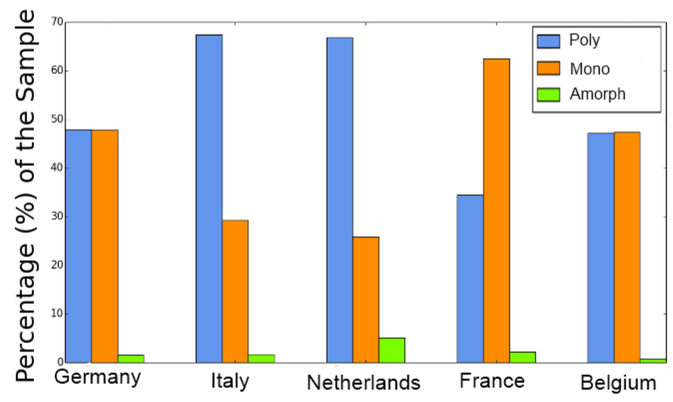
Irradiation data was available only for systems in the Netherlands from 31 ground stations of the Royal Netherlands Meteorological Institute (KNMI). Every PV installation was linked to nearest meteo station. Plane of array irradiation was calculated using the Olmo model [3].

For other countries, reliable irradiation data was not available, so only specific yields could be determined.

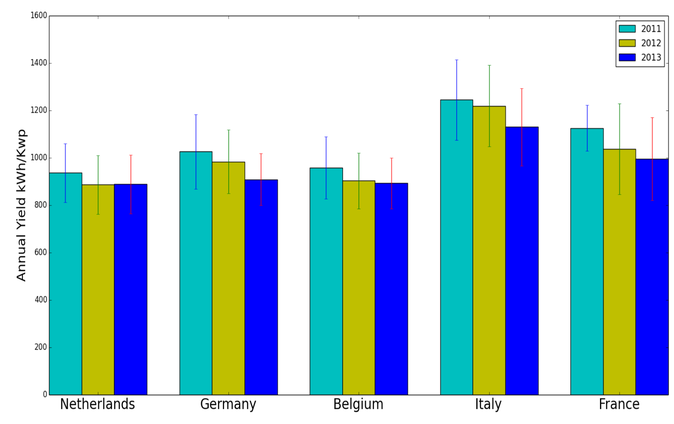
Results

Country comparison

- Majority of the installations belongs to the mid-range category as 45% of the total sample is below 5 kWp in size.
- Module technology varies per country: mono/poly Si most popular.
- Amorphous silicon type modules are mainly used in >15 kWp installations.



Country	#systems	Average system size (kWp)
Netherlands	728	11.1
Germany	764	15.6
Italy	532	13.1
France	325	15.1
Belgium	565	6.5



- PV systems in Southern (European) countries have achieved higher yields than the Northern ones
- Descending tendency between the years 2011 and 2013 (Netherlands: -2%, Germany: -11%)
- North/South division per country: 10-18% yield differences

Country		2011	2012	2013
Germany	North	979±153	937±126	882±109
	South	1081±154	1044±121	992±125
France	North	1030±362	993±201	959±154
	South	1099±96	1092±224	1103±166
Italy	North	1219±170	1177±157	1094±148
	South	1352±113	1337±199	1288±203

Acknowledgement

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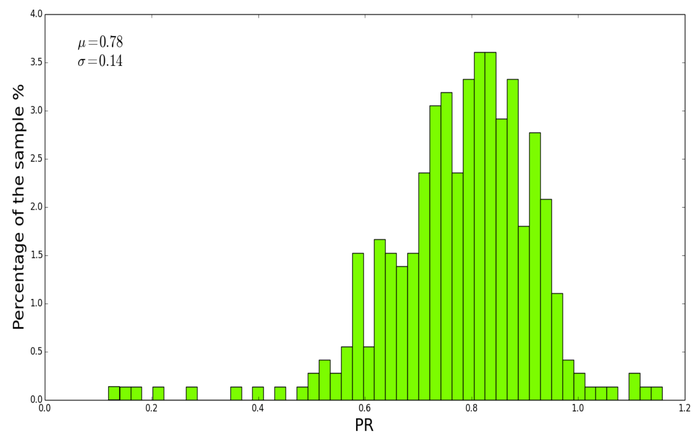
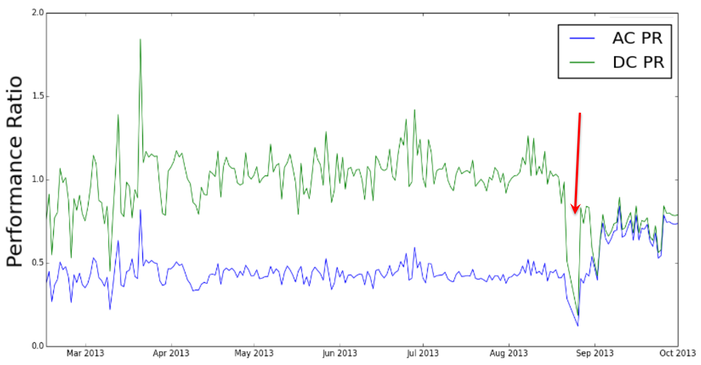
Performance ratio in the Netherlands

- Performance Ratio 78% for the years 2012 and 2013
- Distribution is wide
- Annual yield was 865 kWh/kWp (2012) and 874 kWh/kWp (2013)
- Amount of malfunctioning systems with annual yield less than 600 kWh/kWp has dropped from 5.6% to 3.2%
- 7 out of 10 systems with PR values less than 50% have improved their performance.



Malfunction detection

- Analysis of AC and DC PR shows average DC/AC conversion loss of 5.7%
- Some systems show loss of 10-67%: wire losses, inverter malfunction, shading
- Type of system failure could be identified by studying the difference between AC and DC PR values
- Example: substring malfunction recognized and repaired



Conclusion

- Web scraping of public data sources demonstrated yield differences in some European countries
- Performance ratio in the Netherlands is widely distributed around 78%
- Creation of large databases with high-resolution performance information can be used to identify reason for low performance

References

[1] Solar Log, http://www.solar-log.com/en/home.html

[2] IEC 61274, Photovoltaic system performance monitoring – Guidelines for measurement, data exchange and analysis, 1998.

[3] F.J. Olmo, J. Vida, I. Foyo, Y. Castro-Diez, L. Alados-Arboledas, *Prediction of global irradiance on inclined surfaces*, Energy 24 (1999) 689-704.

[4] IEA PVPS Task 13: http://iea-pvps.org/index.php?id=57.