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Visualization of Operational Performance of Grid-Connected PV Systems in selected European Countries

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Introduction

In this paper a novel approach in large scale operational PV performance monitoring is achieved. A continuously increased number of PV system owners of small and medium installations are using various web platforms to monitor their systems. By employing web scraping techniques we were able to collect a large number (15,917) of systems with 337MWp of total capacity that provided detailed yield data at high time resolution (5-15 minutes) continuously for at least one year. We further used geographical information system (GIS) software to visualize yield and performance ratio in color-coded maps, which greatly facilitate assessment of performance for large amount of geographically scattered systems. The software that we developed in this research in order to extract online data was able to simulate human navigation through web sources, to locate and save scattered information that was available to the user, and finally to organize that information in datasheets.

Results

In order to calculate Performance Ratio, irradiation data is required. For the Netherlands we used the 31 ground-based stations of the Royal Netherlands Meteorological Institute (KNMI) that provided hourly global horizontal irradiation data. Every PV installation was linked to the closest station according to geographical coordinates. The total plane of array irradiation was calculated on an hourly basis using the Olmo model for every system independently in accordance with the orientation and the tilt of each panel.

The majority of the systems in the total sample were installed between 2010 and 2014 with 54% of them being less than 10kWp and only 1.7% being larger than 50kWp. Polycrystalline and monocrystalline cells being the most popular, accounting for 44% and 45.8% respectively. Amorphous silicon panels (1%), CIS (1.4%) and CdTe (2.9%) have smaller shares among the sample. The Performance Ratio analysis that was conducted of the sample from the Netherlands revealed a PR value of 79% for the years 2012 and 2013 and 81% for 2014. The Performance Ratio analysis that was conducted of the sample from the Netherlands revealed a PR value of 79% for the years 2012 and 2013 and 81% for 2014. By performing ANOVA it was found that despite the fact that there was no statistical difference between monocrystalline and polycrystalline technologies (P values between 0.07-1.05), there was strong evidence that the other panel (a-Si, CIS, CdTe) types could have a significant effect on the system yield,

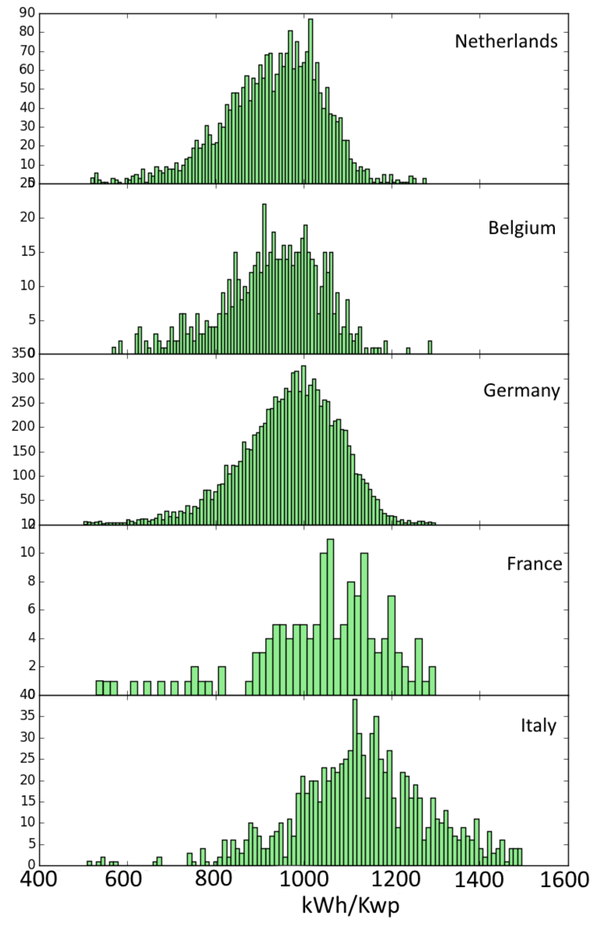

Figure Histograms depicting the annual system yield for PV systems in Netherlands, Belgium, Germany France and Italy.

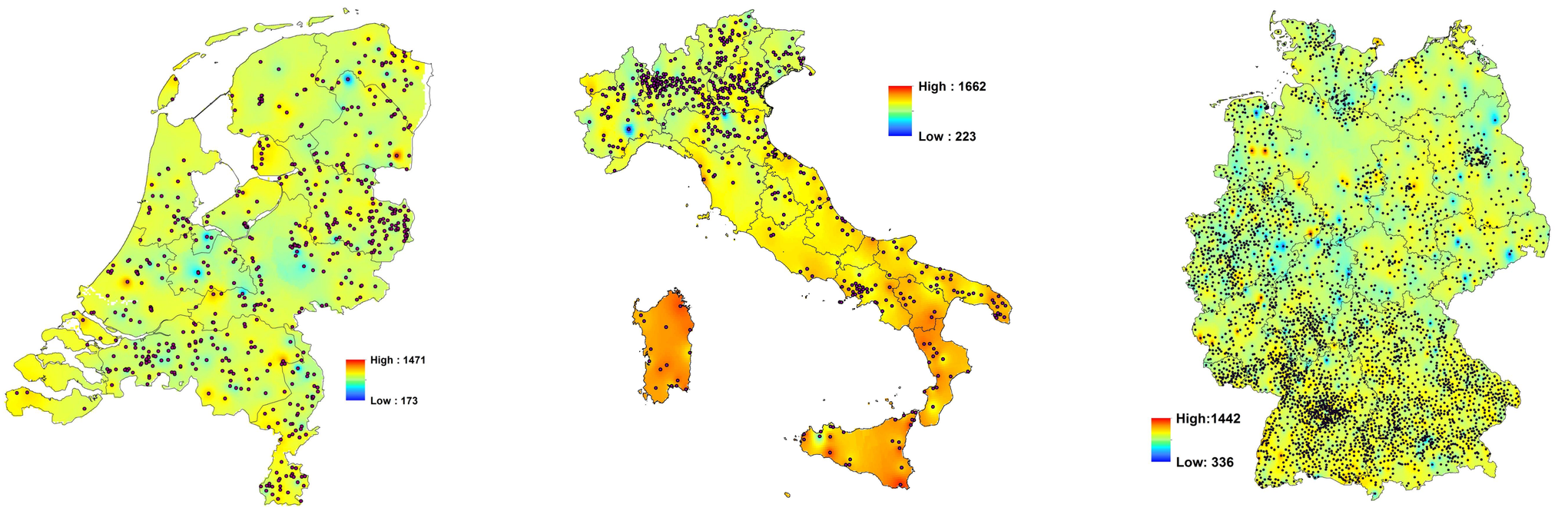

Figure Color-coded GIS map of Annual Yield for the year 2014, Netherlands, Italy and Germany. Black dots indicate installation positions.

Visualization of geographical variation

A Geographical Information System (GIS) is a suitable tool to visualize geographical variation of parameters. By projecting the results on GIS maps we can have a complimentary tool to solar irradiance maps that are usually coming from ground stations or satellite measurements. Performance Ratio and Yield maps can offer high resolution, real time performance overview that can be used as an alternative solar resource assessment tool for optimum site selection, planning and project design, grid integration and smart grid studies.

Conclusions

- Web platforms can be used as a source for high quality Energy and Power data.
- High resolution data can be used for solar forecasting, peer to peer performance assessment and malfunction detection.
- Compared to irradiation maps it has the advantage of being a direct performance overview method.
- GIS maps is an excellent tool for visualization, they can depict in real time systems on country, region or district level.