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TOPIC 6: PV Systems - Performance, Applications and Integration

A Health Check Of The Italian Solar Photovoltaic Park Using Satellite-Based Solar Resource Data

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Summary

With a share of 8.4% of electricity consumption covered by solar electricity, in 2016 Italy has become – and potentially still is - the country with the highest penetration of photovoltaics (PV) into its energy mix.

In order to investigate the health status of the Italian PV park as a whole and potential signs of early decline, we plot first the evolution over time (2005-2017) of performance ratio PR data calculated for Italian regions, and notice a significant discrepancy between PR values calculated for different regions. PR values are calculated by combining solar electricity data (for regions/provinces) made available by the GSE with highly accurate satellite-based solar resource data provided by Solargis.

In order to describe the strong discrepancy in PR between difference regions, we increase the spatial resolution to the province level, and plot 2016 PR data (a year for which solar resources have been in line with long-term averages) for the different provinces as a function of a set of parameters. Including: (1) morphological parameters (e.g. province elevation), (2) average size of PV systems, (3) building density in the province and other parameters.

The effect of elevation (mean and median values) on PR is not clear, nevertheless, not necessarily provinces located at higher altitudes (and potentially increasingly affected by shading) have lower PR's. Similarly, it is difficult to observe a clear correlation between average system size in the province and PR for average sizes below 45 kW. On the other hand, above this threshold, system size is generally a good indicator of good performance. Apparently, the building density in the province (which can be correlated to some extent to increase shading losses, particularly for small/medium-size rooftop installations) has a strong impact on PR and can be described by a hyperbolic relation. A correlation of PR values with building density for different classes of province average size of PV plant is currently ongoing.

Purpose of the work and approach

In order to investigate the health status of the Italian PV park as a whole and potential signs of early decline, we plot first the evolution over time (2005-2017) of PR data calculated for Italian regions. At country level, the average PR for Italy is presently below 70% (68.6% in 2016), a value that is well below the 80-85% value exhibited by well-functioning and properly maintained PV plants. Further, we observe, at regional level, strong dispersions in the results and the presence of some outliers. Regions with the lowest PR are Lombardia, Liguria, and Campania. Puglia, the region with largest average size of solar plants (~58.8 kW in 2016), exhibits the highest PR [1].

To get a better understanding of the picture, we increase the spatial resolution of our analysis by focusing on data from provinces (~108) rather than regions (20) and select data from 2016, a year for which solar resources have been in line with long-term averages (LTA: 1994-2016).

Combining solar electricity data (for regions/provinces) made available by the GSE with highly accurate satellite-based solar resource data provided by Solargis, makes it possible to correlate PV performance indicators (e.g. performance ratio PR) with other parameters. Including: (1) morphological parameters (e.g. province average elevation), (2) average size of PV systems, (3) building density in the province and others.

Solar resource for Italy was carried out using a satellite model developed by Solargis. The inputs to the model are multispectral satellite images from Meteosat satellite and atmospheric parameters like aerosols and water vapour. The spatial resolution of solar data products is enhanced to 250 m. The primary temporal resolution of satellite data is 15 min. The atmospheric parameters are updated daily. The air temperature at 2m data is derived from the NOAA Climate Forecast System, with native spatial resolution of approximately 30/20 km and temporal resolution of 1 hour [3-5]. The original spatial resolution of the models is enhanced to 1 km by spatial disaggregation and use of the Digital Elevation Model SRTM-3 [3-5].

Scientific innovation and relevance

With a share of 8.4% of electricity consumption covered by solar electricity, in 2016 Italy has become – and potentially still is - the country with the highest penetration of photovoltaics (PV) into its energy mix. The health status of the Italian PV park as a whole and potential signs of early decline may, therefore, be of great interest to other PV markets, in Europe and elsewhere, which have experienced similar market dynamics (i.e. the presence and sharp phasing of feed-in tariffs incentives). The outcomes of this analysis, with the proper adjustments, will potentially be of use to other countries (including less mature markets and sun-belt countries) and to the PV community as a whole.

By correlating aggregate values for system performance indicators with external parameters, the analysis provides an insight on the factors that may influence performance and could provide an indication on how to improve overall system performance in macro-areas.

Preliminary results and conclusions

Initially we plot the evolution over time (2005-2017) of PR data calculated for Italian regions (not shown in the abstract). On average regional PR seem to increase until 2011 (when 9GW on newly installed capacity were attached to the grid) and then stabilize (with a moderate downward trend observed for some regions). Most surprisingly, we notice a significant discrepancy between PR values calculated for different regions, also for years after 2012-2013 (end of Conto Energia feed-in trariffs) when apparently the data are more reliable.

To get a better understanding of the picture, we increase the spatial resolution of our analysis by focusing on data from provinces (~108) rather than regions (20) and select data from 2016. Solargis database for most of Italian regions and the full country in fact shows that the availability of solar resources in 2016 is well aligned to long-term averages (LTA: 1994-2016).

Fig. 1 shows maps with province resolution of Italy for year 2016 of (a) final yield Yf (kWh/kWp) and (b) performance ratio PR. To obtain the PR, we use average Global Tilted Irradiance (GTI) at optimal tilt (GTI-opta) values calculated for each province.
Understandably, and with some exceptions, Yf (kWh/kWp) data show in general higher yields in Southern provinces, where the availability of solar resources is higher. On the other hand, by plotting PR data (independent from solar resources), we notice that the picture is much more blurred.

In order to describe the strong discrepancy in PR between difference provinces, we plot 2016 PR data (PR-2016) for the different provinces as a function of a set of parameters. Including: (1) morphological parameters (e.g. province elevation, Fig. 2(a)), (2) average size of PV systems (Fig. 2(b)), (3) building density in the province (Fig. 3) and other parameters (not shown in the abstract).

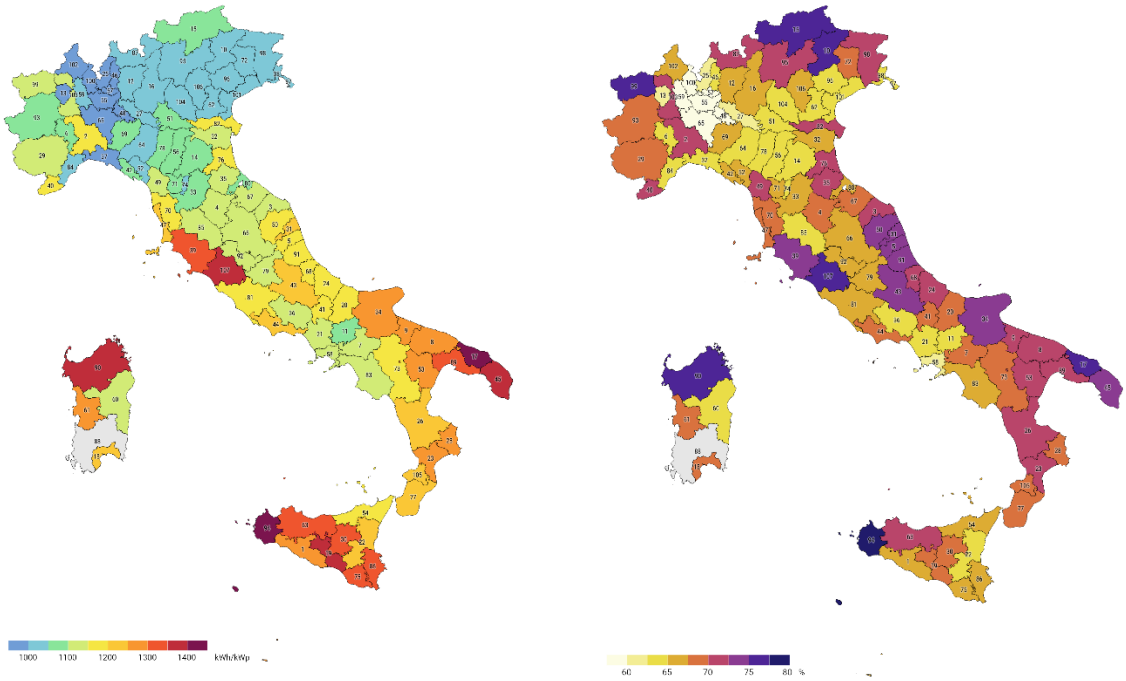

Fig. 1: Maps with province resolution of Italy for year 2016 of (a) final yield Yf (kWh/kWp) and (b) performance ratio PR.

The effect of elevation (mean and median values) on PR is not clear; nevertheless, not necessarily provinces located at higher altitudes (and potentially increasingly affected by shading) have lower PR's. Similarly, it is difficult to observe a clear correlation between average system size in the province and PR for average sizes below 45 kW. On the other hand, above this threshold, system size is generally a good indicator of good performance.

Apparently, the building density (see Ref. [6] too) in the province (which can be correlated to some extent to increase shading losses, particularly for small/medium-size rooftop installations) has a strong impact on PR that can be described by a hyperbolic relation. A correlation of PR values with building density for different classes of province average size of PV plant is currently ongoing.

A detailed uncertainty analysis on the calculated PR values will then be included in this paper.

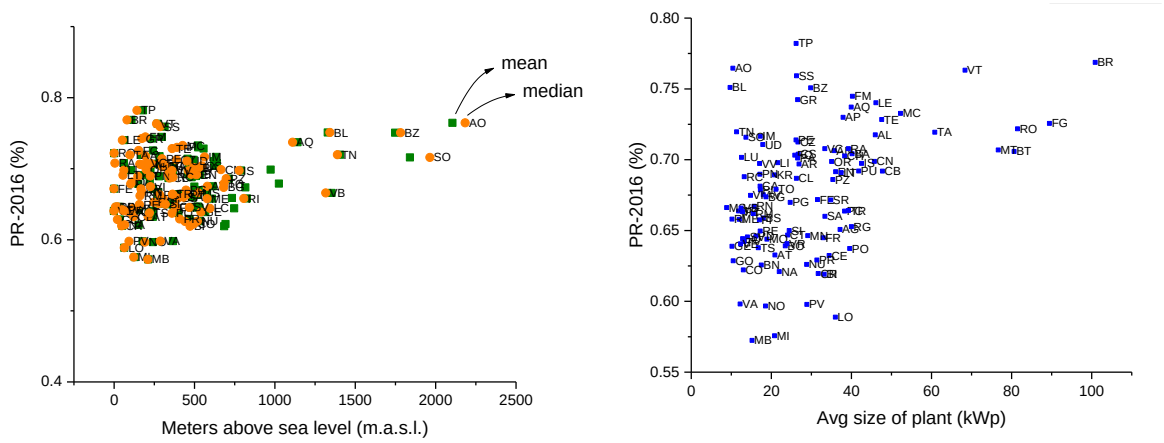

Fig. 2: PR values calculated for Italian provinces in 2016 and correlation to (a) elevation (m.a.s.l, mean and median elevation of province), and (b) average size of PV plant.

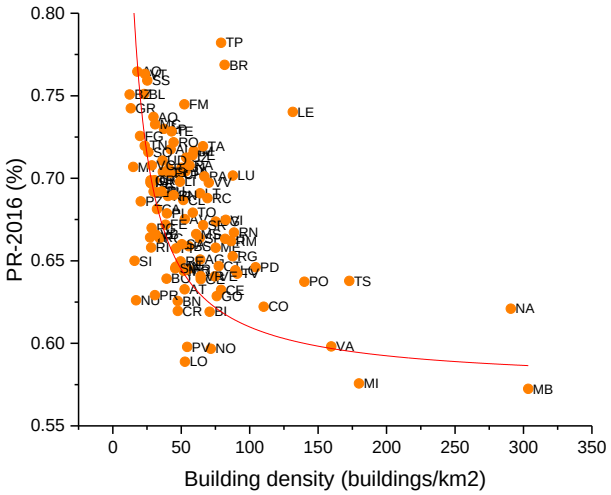

Fig. 3: PR values calculated for Italian provinces in 2016 and correlation to the building density in the province.

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