Quantifying PV fleet output variability in the UK: Consequences for Distribution Network Operators

**Introduction**

Network operators and researchers in the field of electrical grids still lack a precise knowledge of the dynamics of PV output power fluctuations. Network operators currently cope with this problem by oversizing their network, and by limiting the PV power to be integrated. This work explores the correlation/synchronicity between PV generation time-series using an ensemble of several thousands of real systems. We apply simplified geostatistical techniques in order to identify the spatial separation of PV systems beyond which the generation becomes decorrelated.

**Data & Method**

- Distributed PV generation data collected via the Microgen Database website [1].
- Influence of shading on the pairwise comparisons, minimised by only considering readings in the summer months between 08:00 and 16:00 GMT.
- Effects due to clear-sky conditions isolated by classifying days as clear-sky (CS) or variable sky (VS) – see figure 1.

**Employed method similar to that of Elsinga et al. [2] - empirical semivariograms plot the standard deviation in the power fluctuations of pairs of PV systems in the time dimension as a function of the spatial separation:**

- Power readings normalised to the system peak power, assuming no relevant degradation in peak power (systems are relatively new).
- Normalised power readings converted to power fluctuations for each system: $\text{power fluctuation}(t) = \text{power}(t+1) - \text{power}(t)$ [3].
- Systems compared on pairwise basis to calculate the standard deviation in the $y = -x$ dimension.
- Exponential fit (equation 1) applied to the semivariogram to calculate the decorrelation length when variance reaches 95% of the sill, s (equation 2).

$$\sigma_{ij|d} = (s-n) \left(1 - e^{-\frac{d}{\delta}}\right) + n$$

$$\left(1 - e^{-\frac{3b}{\delta^2}}\right) \approx 95\%$$

**Results**

- Separations on a length scale less than or equal to the approximate length scale of low voltage (LV) networks show a correlation coefficient close to 1.
- As in the Netherlands [2], exponential fit is not appropriate under CS conditions since $\sigma^2_{ij|d}$ is low over all pair separations.
- Under CS conditions (when both systems in each pair experience CS day), 30-min power fluctuations in PV generation correlated over separations up to 350 km.
- Decorrelation length for 30-min power fluctuations under VS conditions found to be 15.6 ± 0.3 km.
- Dispersion of points around the fit implies some stochastic decorrelation present at all length scales.

**Conclusion**

Our results suggest that on a clear-sky day, at 30-min resolution, a single PV generation time series at can be used to represent the generation from other identical systems within a loci of 350 km, provided both experience CS conditions, whilst under VS conditions, the equivalent loci is 15 km. We have identified that some degree of stochastic decorrelation should be introduced to the generation time series of all systems.

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**References**

