How weather and grid distribution determine PV forecast error integration costs

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Objective & Background

While solar PV is becoming the cheapest form of renewable generation per kilowatt capacity, the system integration costs become large as penetration increases (Hirth). Minimising these costs is important as they influence the profitability of solar PV investments and the viability of high solar penetration solar electricity grids for network planners.

Relatively little literature focuses on the integration costs of solar PV. This talk examines the integration costs for individual systems due to forecast errors in the context of the wider electricity grid, including:

- What is the financial and system cost of forecast errors?
- How system configuration and location determines these costs
- What is the optimal distribution of solar PV to minimise system costs?
- What is the impact of increased PV penetration?

Method

This work uses empirical analysis carried out by creating a model for solar power on the UK grid. This is based on building forecasts for 10,000s of PV sites combined with installed PV capacity. Market prices are used to create forecast loss figures. The analysis is performed over almost ten years of history, allowing trends over time to be measured.

Further, a theoretical framework is developed to allow measurement and examination of the key driving factors. This model is used to simulate what the evolving trends indicate for the financial value of solar farms in the future and the implications for the planning of the distribution of PV sites.

Principal Findings

The results showed clearly that forecast error losses have a strong geographical dependence. Forecast losses peaked at 5% of solar farm revenues in the central locations of the UK grid, and declined to zero at the periphery of the grid. Similarly a strong forecast cost signal is observed in the PV system orientation. It is shown how the correlation of forecast errors is the key driver of these results.

Modelling the forecast errors losses over time and PV penetration shows that while the correlation of net system-wide PV forecast errors is increasing with respect to market price movements, the potential for increased losses is decreasing as the balancing market becomes more efficient.

Conclusion & Discussion

The geographical driver of forecast error losses shows the strategies that can be employed to reduce forecast losses for the individual and the system as a whole.

Value cannibalization due to increasing forecast error losses with increasing PV penetration does indeed not seem to be currently a concern, but the effect is potentially being masked by the balancing market having become more efficient in recent years. This leaves the door open that the forecast losses could significantly spike in future years if this trend is reversed.

Further work examining how this interacts with trading strategies and weather regimes would be of interest.

1. Hirth, Lion, and Inka Ziegenhagen. 2015. “Balancing Power and Variable Renewables: Three Links.” Renewable and Sustainable Energy Reviews 50 (October): 1035–51. https://doi.org/10.1016/j.rser.2015.04.180