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The impact of different PV module configurations on balancing needs of a highly renewable European power system

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To ensure reliable energy supply from power systems with high shares of variable renewable energy sources like solar photovoltaics (PV) and wind, it is essential to include balancing options like storage and backup from dispatchable resources. There are multiple factors that can influence these balancing needs, such as the overall renewable penetration to the power system, the mix of PV and wind, and the inclinations and orientations of the PV systems.

In the present study, we have quantified the balancing requirements for Europe and analyzed how they are influenced by all these factors, specially by changing PV module configurations. For this work, solar irradiance is retrieved from Meteosat first and second generation satellites while wind speed (i.e. power) is derived from numerical weather prediction on a 7km $\times$ 7km grid for all European countries. The data is described in more detail in (RESTOREreport).

We have analyzed multiple scenarios with different degrees of renewable penetration and different PV and wind shares and identified the module configuration that minimizes balancing needs in each of these scenarios. We show that in presence of a storage, balancing needs are mainly governed by the seasonal patterns of generation and load. Our analysis indicates that for high solar shares, highly inclined modules with a less pronounced annual course are favorable, if a storage with a capacity to cover at least 6 hours of average hourly load is available to compensate for the day-night cycle of PV. In a wind-dominated scenario, lowly inclined East/West facing modules are most suitable to reduce balancing needs. In absence of storage, balancing needs completely rely on backup supplies and are steered by diurnal behavior of generation and load. West facing modules, which peak around the same hours as the European load curve, are favorable compared to the more common South facing optimally inclined modules in such storage-free scenarios.

A further enhancement in balancing reduction potential can be achieved by combining East and West facing modules as long as the solar share is high enough to maintain the bell-shape of the diurnal generation curve. This combined East and West facing modules can be used when repowering old PV systems. This can strongly reduce balancing needs and can be beneficial in the long run (Chattopadhyay2017).

References

(RESTOREreport) A. Kies, K. Chattopadhyay, E. Lorenz, L. von Bremen, and D. Heinemann. Simulation of renewable feed-in for power system studies. RESTORE 2050 project report. Institute of Physics, University of Oldenburg. 2016.

(Chattopadhyay2017) K. Chattopadhyay, A. Kies, E. Lorenz, L. von Bremen, and D. Heinemann. The impact of different PV module configurations on storage and additional balancing needs for a fully renewable European power system. Manuscript under review.