Fat Tails due to Variable Renewables and Insufficient Flexibility: Evidence from Germany

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The large-scale integration of renewable energy sources (RES) requires flexibility from power markets in the sense that the latter should quickly counterbalance the renewable supply variation driven by weather conditions. RES supply, being a variable source of power production, poses challenges to power markets as they are often not flexible enough to counterbalance RESs variation in production volumes, since power storage is insufficient and power demand is inelastic.

Research shows that the volume of renewable energy in the supply system affects the mean and volatility of power prices. Using extreme value theory, we extend this view and show that the level of wind and solar energy supply affects the tails of the electricity price distributions as well, and that it does so asymmetrically. The higher the supply from wind and solar energy sources, the fatter the left tail of the price distribution and the thinner the right tail. In other words, we demonstrate that the tails of the power price probability distribution are fatter when the supply of flexibility is low. Such moments of low power flexibility occur when both the reserve margins of non-intermittent suppliers and RES supply are either at low or at high levels. More specifically we find support for our claims that i) during periods of high share of RES, the left tail is fatter than the right tail and the difference in fatness will be more pronounced when demand is lower, and ii) during periods of low share of RES, right tail is fatter than the left tail and the difference in fatness will be more pronounced when the demand is higher. When we focus separately on the share of wind and solar supply, instead of aggregate supply from RES, we find the same results for wind and for solar.

Although it was already known that power prices are not normally distributed, this paper shows that the amount of non-normality in the tails, i.e. the tail fatness, can be forecasted by demand and volume of RES. For risk managers, this implies that risk models should be made conditional on those variables and one should use models in which the tail structure can be flexibly adjusted to the supply and demand conditions. This implies that one cannot rely on symmetric price distributions for risk management and for valuation of (flexible) power assets.

Furthermore, in order to achieve large-scale integration of RES in the power system, policy makers and market participants should have a clear understanding of the requirements for power system flexibility. This study provides insights into when, and to what extent, extreme prices occur depending on the electricity demand and RES supply, and thereby the demand for flexibility to adjust electricity supply through non-intermittent producers. The evidence in this paper suggests that we have to rethink the methods of sub-

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sidizing variable renewable supply such that they take into consideration also the flexibility needs of power markets.