Assessing price effects of RES infeed and its regional distribution in nodal markets: A case study for Germany

(3) Integrierte Netze der Zukunft
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Motivation und zentrale Fragestellung

The market-based dispatch of generation units in Germany's bidding zone often leads to congestions in the electricity system, resulting in a significant dependency on redispatch. In contrast to a market design based on uniform prices, a nodal pricing regime internalises grid capacity in the market resulting in different Locational Marginal Prices (LMPs) in case of congestions.

Our paper investigates how today's regional distribution of installed RES capacities impacts diverging LMPs. This is an essential aspect in market design discussions around nodal pricing as it influences the remuneration potentials of RES and potentially set regional investment incentives on the supply and demand side.

Methodische Vorgangsweise

This paper’s approach bases on a linearly formulated optimisation problem of the German electricity system in hourly resolution, including generation, load, storage and transmission capabilities. The model minimises total system costs while respecting constraints, such as always ensuring load coverage and not overloading transmission lines. The electrical flows are simplified considered by applying a DC load flow approach. The model was formulated with the free software toolbox PyPSA [1].

The model's underlying data are mostly based upon DIW Berlin's Reference Data Set representing the status of the German electricity system in 2015 [2]. This database is updated with own assumptions to represent the year 2020. Additionally, we simulate scenarios for the years 2023, 2025 and 2030 to investigate the impacts of grid extension measures, phase-out of conventional generation capacities, and further RES deployment. Nodal-based profiles for wind turbines are calculated through ERA5 wind data derived from Copernicus Climate Data Store [3].

For assessing the impact of RES infeed on diverging LMPs, we applied statistical instruments, such as regression analyses and calculation of correlation coefficients, to determine the statistical significance. We carry out these analyses for different sensitivities in which we assume other regional distributions of future RES deployment.

Ergebnisse und Schlussfolgerungen

Our results show that congestions exist in all modelled scenarios, resulting in regionally different LMPs. Congestions resulting in high divergencies are already visible today and increase in the 2023 scenario mainly due to fewer conventional generation capacities in Southern Germany. In contrast, fewer congestions are identified for the 2025 and 2030 scenarios, where we anticipated significant progress in grid extension. Particularly, large HVDC projects reduce price divergencies once they become operational.

Our analyses identify wind infeed to have the biggest impact on diverging LMPs, as Figure 1 illustrates for the 2020 scenario. We show with statistical significance that the higher the wind infeed is, the higher the probability of diverging LMP becomes. Even the anticipated grid extension measures for future scenarios are not sufficient to fully eradicate this effect. The PV infeed has almost no impact on price divergencies.

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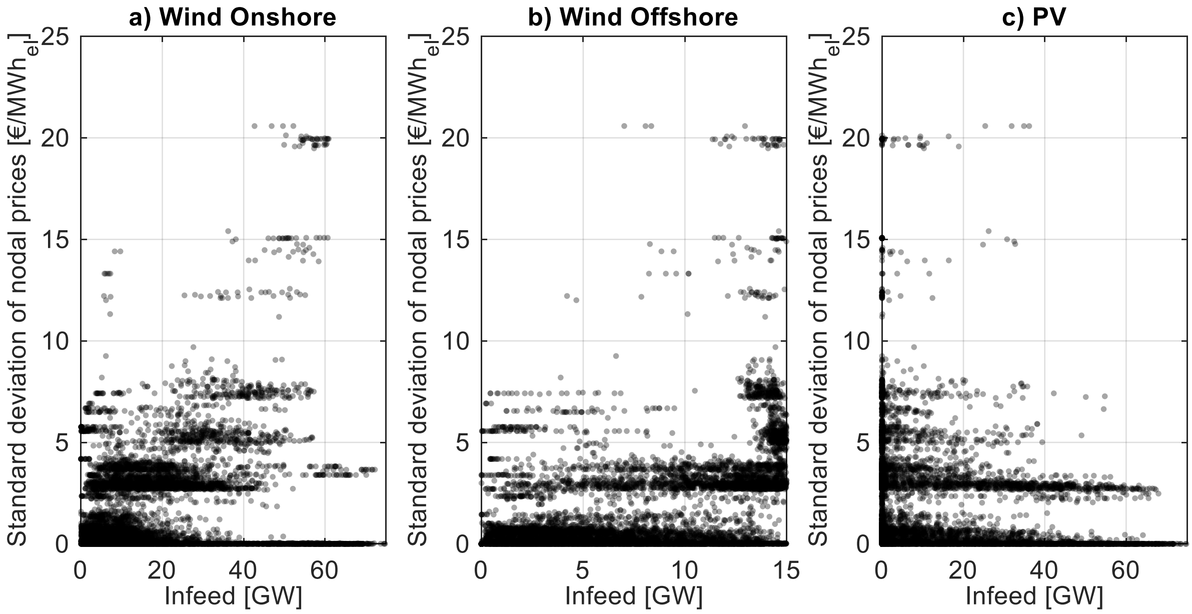

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Figure 1: Modelled correlation between the standard deviation of nodal prices and the infeed of a) Wind Onshore, b) Wind Offshore, and c) PV in the 2020 scenario

We conclude that the regional distribution of RES matters. Considering regional aspects for the future deployment of RES can become vital for ensuring that renewably generated electricity can be best utilised.

Literatur

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