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Hedging Renewables with Location Spreads

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The ongoing decarbonization of the power sector has fundamentally transformed electricity markets in many countries. In countries like Germany, renewable production accounts for a dominant share of the overall production (see Bundesnetzagentur SMARD (2025)). As a consequence, the risk profile of power producers has shifted: instead of relying primarily on controllable thermal power plants with predictable output, market participants must now manage the risks associated with weather-driven renewable production. Because renewable energy is produced with negligible marginal costs, the key quantity for a renewable producer and its risk management is the revenue. There are two main uncertainties in the revenue of renewable producers: how much energy can be produced depending on the weather conditions and at what price it can be sold on the market. A crucial feature of renewable-dominant electricity markets is that these two sources of uncertainty are not independent. Due to the merit-order mechanism, high renewable generation in the market tends to decrease electricity spot prices, while low infeed is associated with higher spot prices (see e.g. Cludius et al. (2014)). The same weather conditions that affect the divergence in the quantity of renewable generation also affect the price level. The revenue risk faced is therefore a joint price-quantity risk (see e.g. Pircalabu et al. (2017)).

To manage revenue risks, electricity producers commonly rely on power futures. Standard hedging strategies typically use futures written on the electricity price of a single bidding zone, e.g. the German power futures. These contracts are designed primarily to fix the price level for a given delivery period. The hedge ratio is based on ex-ante production forecasts. Since the most liquid futures are monthly contracts requiring mid-term forecasts, this leaves substantial residual revenue risk: volume deviations remain unhedged and the merit-order–induced correlation between price and quantity risk is ignored.

The German power market is highly integrated into the European electricity system through cross-border interconnections and market coupling (see Estermann et al. (2025)). Nevertheless, price differences between bidding zones frequently arise due to network constraints and limited transfer capacities (see Kiesel and Kusterman (2016), Kargus and Uhrig-Homburg (2025)). These location spreads depend on the level and spatial distribution of renewable generation and tend to widen when interconnector limits bind during periods of high renewable infeed (see Kargus and Uhrig-Homburg (2025)). Consequently, renewable production uncertainty affects not only domestic prices and output but also cross-zonal price spreads. This observation motivates the central idea of the paper: instead of relying on national futures to hedge revenue risk, renewable producers may exploit futures written on different markets or the direct trade of power future spreads. Such strategies explicitly target the price differences between markets and are better aligned with the underlying drivers of renewable revenue uncertainty in an integrated, renewable-dominant European power system. This motivates the following research question: how effectively can renewable producers in Germany hedge their revenue using location spreads?

The study contributes to the literature on hedging in electricity markets (e.g. Byström (2003), Zan-otti et al. (2010), Pircalabu et al. (2017), Hanly et al. (2018), Christensen and Pircalabu (2018)) by focusing on intermittent renewable producers with stochastic output and comparing the hedging effectiveness of national power futures and cross-zonal location spreads. Furthermore, it is connected to the general finance literature regarding hedging and builds on the classical minimum-variance hedging framework (see Ederington (1979)). Third, the analysis relates to the literature modeling uncertainty in electricity markets (e.g. Bessembinder and Lemmon (2002)) as well as studies explicitly modeling the joint distribution of spot prices and generation output (e.g. Pircalabu et al. (2017)). Lastly, it contributes more broadly to the literature of market coupling (e.g. Cartea et al. (2022), Pierre and Schneider (2024)) and the revenue cannibalization in electricity markets (e.g. Prol et al. (2020)).

The hedging effectiveness is evaluated using descriptive evidence and both reduced-form and structural models of renewable revenues and futures payoffs. Using realized hourly price and infeed data from ENTSO-E (2026) as well as daily settlement prices for futures from Bloomberg (2025), location spreads exhibit substantially higher correlations with renewable revenue innovations than the German baseload future. The structural Monte Carlo simulations confirm that hedging performance is technology-specific and that accounting for spatial price differentials improves renewable revenue risk management. Overall, the results indicate that location spreads can complement standard price futures and help mitigate revenue risk.

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