Impact of Latitude on European Electricity Prices: A Data-Driven Analysis

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July 21, 2025

Abstract

This study quantifies how geographic latitude influences day-ahead wholesale electricity prices across 18 European market zones. Using EPEX SPOT data for 2021–2025 and a random forest regression, we find latitude to be the single most important predictor (importance ≈ 0.74), with the model explaining 47% of price variance (MAE ≈ 26 EUR/MWh). These results underscore the role of regional renewable mix and grid integration, as northern countries with abundant wind and hydro experience more stable prices than southern counterparts [Koutantou et al., 2025, Navia and Anadon, 2025].

1 Introduction

Electricity price disparities across Europe arise from structural, meteorological, and geographic factors. The 2022 energy crisis highlighted that southern and eastern markets suffered substantially higher spot prices than northern regions [Cevik and Ninomiya, 2022, Kohlscheen and Moessner, 2022]. Latitude serves as a proxy for renewable penetration and interconnection: higher-latitude zones benefit from strong wind/hydro resources, stabilizing prices, whereas lower-latitude areas depend more on gas and face weaker grid links [University, 2023].

This paper focuses exclusively on the latitude–price relationship. We employ a multiple linear regression and a random forest model to assess how much of price variation can be attributed to geographic position, controlling for hour-of-day effects.

2 Data and Methodology

2.1 Data

We collect hourly day-ahead prices for 18 European zones (e.g., AT, BE, CH, NO4) from EPEX SPOT for January 2021 through June 2025 [Energy, 2024, Intercontinental Exchange (ICE), 2025]. These data were retrieved from the open repository at `https://raw.githubusercontent.com/tvanlaerhoven/epex-client/main/data/`. Each observation records the date, hour, price (EUR/MWh), and the zone's central latitude (e.g.,

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AT 47.5°N, FR 46.2°N, NO4 65.0°N). After cleaning and merging, the dataset includes 85,920 rows with 24 hourly dummy variables and latitude.

2.2 Methodology

We specify:

$$P = \beta_0 + \beta_{\text{lat}} \times \text{Latitude} + \sum_{h=1}^{23} \beta_h \, \text{Hour}_h + \epsilon, \tag{1}$$

for the linear model. Additionally, we fit a random forest regressor (100 trees, max depth 10) using scikit-learn [Pedregosa et al., 2024]. We evaluate both models via R^2 and MAE, and extract feature importances from the forest.

3 Results and Discussion

The random forest model achieves $R^2 = 0.466$ and MAE 26.11 EUR/MWh, substantially outperforming a naive mean predictor. Feature importance rankings reveal latitude (0.7418) as the dominant driver, far exceeding all hourly effects (next-highest 0.0451) (Table 1).

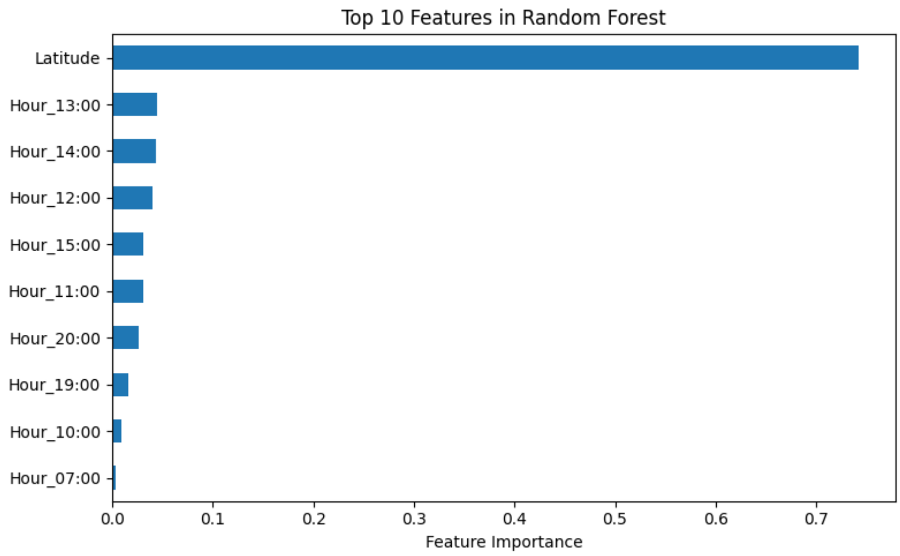
Table 1: Top-10 Feature Importances (Random Forest)

Feature	Importance
Latitude	0.7418
Hour_13:00	0.0451
Hour_14:00	0.0439
Hour_12:00	0.0402
Hour_15:00	0.0314
Hour_11:00	0.0312
Hour_20:00	0.0263
Hour_19:00	0.0161
Hour_10:00	0.0095
Hour_07:00	0.0036

These findings indicate that southern European countries incur higher wholesale prices than northern ones—a pattern echoed by Reuters (2025), which reported prices in Greece and Italy up to 12× those in Nordic markets [Koutantou et al., 2025]. The latitudinal gradient reflects deeper factors such as renewable share and grid interconnectivity; high-latitude zones benefit from diversification into wind and hydro, damping price spikes [Navia and Anadon, 2025].

4 Conclusion

Our analysis confirms that geographic latitude is the primary determinant of day-ahead electricity prices in Europe, accounting for nearly three-quarters of model importance and explaining close to half of price variance. These results highlight the value of strengthening renewable capacity and grid links in southern regions to reduce price disparities.



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Press release (Nature Energy study).