EU27 ELECTRICITY MIXES AND THE IMPACT OF RENEWABLES ON HOUSEHOLD ELECTRICITY PRICES

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Overview

This study examines the current structure and historical evolution of electricity mixes across the EU27 Member States, particularly in light of recent economic volatility and geopolitical tensions. The analysis is situated within the broader context of the European Union's commitment to achieving carbon neutrality by 2050 and considers the impact of the EU Emissions Trading System (EU ETS), the European Green Deal, and related legislative measures (European Commission, 2019, 2021, 2022; European Parliament and Council, 2023). The aim of this study is to assess the effect of the increasing share of renewable energy sources (RES) in national electricity mixes on electricity prices for household consumers in the EU27 between 2012 and 2023. We use purchasing power standards (PPS) to reflect cross-country differences in price levels and to ensure comparability of household affordability across Member States. Our study contributes to the existing literature by focusing specifically on the post-2012 period marked by the implementation of the 2030 climate and energy framework, increased RES penetration, and significant geopolitical and market shocks affecting electricity prices across Europe. Existing research shows that a growing share of renewable energy sources is associated with reductions in wholesale electricity prices (see Sensfuß, Ragwitz and Genoese (2008); Hirth (2013); Dillig, Jung and Karl, (2016); Ballester and Furió, (2015)) primarily due to the merit order effect, a relationship that has been explored in the literature. In contrast, the effect on electricity prices for households remains less clear, as it is shaped by a range of factors including necessary investments in electricity transmission systems, taxes, levies, and national support mechanisms, revealing a gap in empirical research on the retail-level impacts of renewable integration. Oosthuizen, Inglesi-Lotz, and Thopil (2021) analyzed the impact of RES on electricity prices using panel data from 34 OECD countries covering the period 1997–2015. Their results indicate a positive relationship between RES penetration and retail electricity prices. While the authors suggest that this upward effect is marginal and expected to decline over time, our findings show that the effect persists in the EU27 even during the more recent period of 2012–2023.

Methods

Our analysis employs a dynamic panel data model with an error correction representation and pooled mean group estimations (panel ARDL), covering the EU27 countries over the period 2012–2023. As a dependent variable, we use **electricity prices for household consumers (in PPS)**, for the standard consumption band DC (2,500–4,999 kWh annually). These prices include taxes, levies and VAT. For explanatory variables, we use **(1) Share of renewables (RESEL)**: the share of renewable energy sources (solar, wind, hydro, and other RES) in gross electricity generation; **(2) GDP per capita in PPS (GDPpc)**: a proxy for economic development and purchasing power; **(3) EU ETS allowance price in PPS (ETS):** the average annual carbon price under the EU Emissions Trading System expressed in PPS; and **(4) Energy imports dependency (EID):** net imports as a percentage of gross available energy, indicating external energy reliance.
The model equations are as follows:
Long-run equilibrium:

$$ln(y_{i,t}) = \beta_1 ln(RESEL_{i,t-1}) + \beta_2 ln(GDPpc_{i,t-1}) + \beta_3 ln(ETS_{i,t-1}) + \beta_4 ln(EID_{i,t-1}) + u_{i,t}$$

Error correction form (short-run dynamics):

$$\Delta ln(y_{i,t+1}) = \varphi ECT_{i,t} + \alpha_1 \Delta ln(RESEL_{i,t}) + \alpha_2 \Delta ln(GDPpc_{i,t}) + \alpha_3 \Delta ln(ETS_{i,t}) + \alpha_4 \Delta ln(EID_{i,t}) + \varepsilon_{i,t+1}$$

Unit root tests confirm that independent variable and most explanatory variables are integrated of the order 1, while import dependency is stationary. Using the Pedroni cointegration test for panel data time series, we found statistically significant cointegration relationship between the dependent variable and explanatory variables of the same order of integration, which justifies the use of a panel ARDL model. The dependent variable is lagged by one period ahead (t+1) to capture structural lags in cost transmission and short-term rigidity in household electricity prices. All nominal variables are expressed in PPS to ensure cross-country comparability within the EU27. This adjustment eliminates distortions from price level differences and allows for a meaningful analysis of real economic conditions and household purchasing power. The forward-shifted dependent variable accounts for the time lag between changes in the energy system and their eventual reflection in consumer prices, capturing delayed effects driven by regulatory adjustments, investment cycles, and short-term price rigidity for household consumers.

The data used in this analysis are drawn from Eurostat (electricity prices for household consumers, GDP per capita in PPS, energy imports dependency), the Ember database (renewables share in electricity generation), and the European Energy Exchange (EEX), the main platform for trading EU ETS carbon allowances. The dataset covers the period 2012–2023 and includes annual observations for all EU27 Member States.

Results

Based on our analysis, several notable long-term trends have emerged in the electricity mixes of EU27 countries over the observed period. First, there has been a significant increase in the share of renewable energy sources, driven by the European Union's political commitments under the Green Deal and related initiatives. This growth also reflects the concept of securitizing renewable energy, emphasizing its dual role in climate protection and strengthening energy independence. Second, the share of nuclear energy has slightly declined, primarily due to the phase-out of nuclear power plants in certain Member States, most notably Germany. However, despite this stagnation, nuclear energy is anticipated to regain prominence in the future, particularly in light of increasing decarbonization demands and the need for a stable and reliable energy supply. Third, the share of coal in electricity generation has dropped sharply (from 26% to 12% between 2012 and 2023), marking one of the most prominent developments across the EU. This decline stems from the implementation of climate goals, particularly those focused on reducing greenhouse gas emissions, and the closure of coal-fired power plants. This trend is especially apparent in traditionally coal-reliant countries such as Germany and countries of Central and Eastern Europe. Finally, the share of natural gas in electricity generation has remained largely stable throughout the period.

As for the model estimation, the results reveal that all explanatory variables exhibit statistically significant long-run relationships with household electricity prices at the 1% significance level. Specifically, the share of renewable energy sources in electricity generation is associated with higher electricity prices for household consumers while GDP per capita (PPS) shows a negative relationship indicating that wealthier countries tend to experience lower electricity prices in purchasing power terms. Additionally, both the EU ETS allowance price and energy imports dependency are positively associated with household electricity prices, suggesting that carbon pricing and reliance on imported energy contribute to upward price pressure. The short-run dynamics indicate significant error correction, confirming convergence in the system toward the long-run equilibrium. As an additional robustness check, the model was also estimated for household consumers in band DD (5,000–14,999 kWh annually), with all explanatory variables remaining statistically significant at the 1% level. These results are consistent with our main model for band DC households and confirm the reliability of the identified long-run relationships.

Conclusions

According to the ARDL model, the results indicate that renewable energy expansion, EU ETS allowance prices, and higher energy import dependency contribute to increasing household electricity prices in the EU27 in the long run. In contrast, higher GDP per capita tends to mitigate these effects. Less economically advanced countries, with lower purchasing power, appear to be more exposed to relatively high electricity prices (measured in PPS), as they bear a greater cost burden from EU ETS allowance pricing relative to other production inputs and have more limited capacity to absorb structural changes in global energy markets due to lower economic development and efficiency. These findings invite further reflection on how current EU and national policy frameworks may contribute to persistently high electricity prices, raising questions about affordability for households and the broader societal acceptability of the green transition.

References

Ballester, C., and Furió, D. (2015). Effects of renewables on the stylized facts of electricity prices. Renewable and Sustainable Energy Reviews, 52, 1596–1609.

Dillig, M., Jung, M., & Karl, J. (2016). The impact of renewables on electricity prices in Germany – An estimation based on historic spot prices in the years 2011–2013. Renewable and Sustainable Energy Reviews, 57, 7–15.

Ember (2025). Electricity Statistics.

European Commission (2019). The European Green Deal. COM(2019) 640 final.

European Commission (2021). European Climate Law. Regulation (EU) 2021/1119.

European Commission (2022). REPowerEU Plan. COM(2022) 230 final.

European Parliament and Council (2023). Directive on the promotion of energy from renewable sources (EU) 2023/2413.

Eurostat (2025). Eurostat Database. Energy Statistics.

Hirth, L. (2013). The market value of variable renewables: The effect of solar wind power variability on their relative price. Energy Economics, 38, 218–236.

Oosthuizen, A. M., Inglesi-Lotz, R., and Thopil, G. A. (2022). The relationship between renewable energy and retail electricity prices: Panel evidence from OECD countries. Energy, 238(Part B), 121790.

Sensfuß, F., Ragwitz, M., and Genoese, M. (2008). The merit-order effect: A detailed analysis of the price effect of renewable electricity generation on spot market prices in Germany. Energy Policy, 36(8), 3086–3094.