To what extent can the integration of alternative means of production based on renewable energies into the production network affect electricity prices?

An econometric approach for the French case.

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Academic year :

2025 – 2026

University :

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Abstract:

This paper analyzes the impact of renewable energy penetration on electricity prices in France over the period 2007–2025 using monthly time-series data. The results show no statistically significant effect of the share of renewable energy on electricity price variations, while gas prices emerge as a key determinant. This outcome reflects the integration of France into the European electricity market, where prices are set by the marginal production unit under the merit-order mechanism. Consequently, electricity prices in France remain strongly influenced by gas market conditions.

Contents

1 Introduction

The energy transition undertaken within the European Union in recent years has profoundly changed the way electricity markets operate. The rise of renewable energies, supported by ambitious public policies, has been accompanied by significant investments and a transformation of price formation mechanisms in wholesale markets. Although renewable energies are characterized by low marginal production costs, their large-scale integration does not necessarily translate into lower final electricity prices. In several European countries, this transition has been associated with greater price volatility and a growing disconnect between wholesale prices and the prices paid by consumers.

In this context, the French case has some notable specificities. The French electricity mix is dominated by nuclear power, supplemented by a growing share of renewable energies, which distinguishes France from many European countries that are more dependent on fossil fuels. However, despite this particular structure, the price of electricity in France has risen steadily in recent years. It therefore seems relevant to empirically analyze the impact of the share of renewable energies on the price of electricity in France, taking into account national specificities and the European institutional framework within which the electricity market operates.

The rest of our article is structured as follows: We will review the literature on the effects of renewable energies on electricity prices, highlighting the mechanisms identified at the European level and their limitations in the French case in section 2. We will analyze recent developments in electricity prices in France between January 2007 and September 2025, highlighting the main causes of the continuous price increases in section 3. We then detail the empirical strategy adopted, presenting the data used, the econometric model, and the methodological precautions related to time series analysis in section 4. Section 5 presents the empirical results and the main findings. Finally, section 6 concludes by summarizing the results and opening the floor for discussion.

2 Literature review

The energy transition and the rise of renewable energies have profoundly changed the functioning of European electricity markets, raising the question of their impact on electricity prices. While renewable energies are characterized by low marginal costs, their impact on prices is not limited to simple downward pressure and depends heavily on the market context and national structures.

At the European level, Cerqueira and Pereira da Silva (2017) show that electricity prices are strongly and positively correlated with changes in fossil fuel prices, particularly gas, as well as with the increase in the share of renewable energies. They find that the latter tends to increase the price paid by households, due to the support mechanisms put in place to finance the development of renewables. This analysis highlights a dissociation between the effect of renewables on wholesale prices and their impact on final prices, but is based on a highly aggregated approach, which limits its ability to explain specific systems such as that of France. It should also be noted that when renewable production is high during periods of low demand, prices can become very low or even negative, while during periods of high demand, renewables can help limit price increases. It is in this context that Sbai and al. (2024) confirm these results by showing that the integration of renewable energies influences prices in a non-linear and demand-dependent manner. High levels of renewable production during periods of low demand can lead to very low or even negative prices, and vice versa. However, these results are based on an hourly analysis of wholesale prices, which limits their transposition to an analysis based on average monthly prices.

Solier (2023) provides a more structural insight by showing that the increase in renewable production at low marginal cost exerts downward pressure on wholesale prices, while undermining the functioning of the market. Dispatchable power plants find it more difficult to cover their fixed costs, even though the price of electricity remains largely determined by the cost of gas-fired power plants. This situation highlights a growing mismatch between the European market model and a mix dominated by zero marginal cost technologies.

Finally, the French electricity transmission system operator (RTE) points out that the wholesale price is set by the last power plant called upon, often a gas-fired plant, which explains the persistent sensitivity of prices to fossil fuels. However, this logic applies specifically in France, where electricity production is mainly based on nuclear power and where final prices are strongly influenced by regulatory mechanisms such as Regulated Access to Historic Nuclear Electricity (ARENH) or regulated tariffs.

Percebois and Pommeret (2019) provide a complementary analysis showing that, in an energy mix dominated by low marginal cost technologies, the marginal cost-based market model becomes unsuitable, causing a gap between the market price and the actual costs of operating the electricity system. This suggests that the relationship between the share of renewable energies and the market price could evolve in a non-linear manner, in addition to being highly dependent on national specificities.

Finally, the existing literature, which largely focuses on gas-dependent markets, offers only partial insights for the French case. This specificity justifies an empirical examination of the effect of the share of renewable energies on electricity prices in France, without assuming that the results observed at the European level automatically apply here.

3 The price of electricity in France

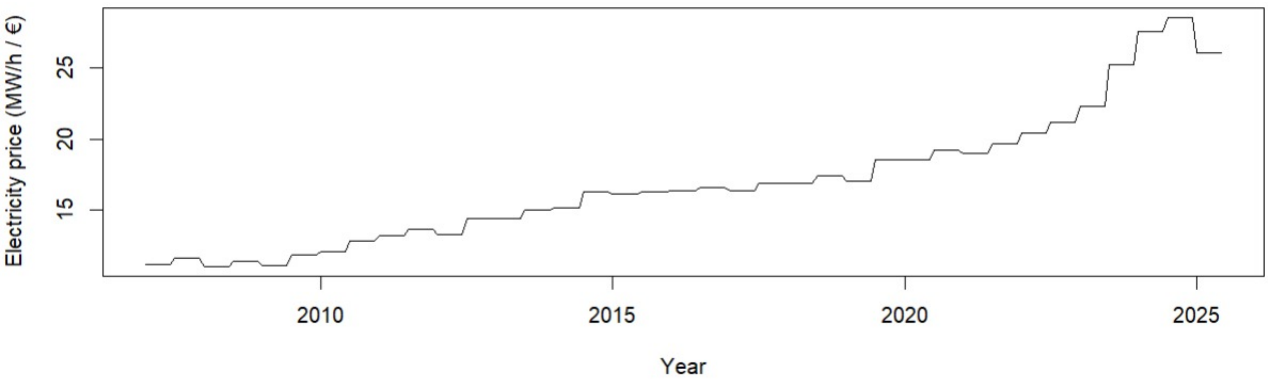

Figure 1: Monthly changes in electricity EN prices in France from January 2007 to September 2025

3.1 The stable period: 2007–2020

Despite the absence of major shocks over the period [2007–2020], electricity prices in France have shown a gradual upward trend over the long term. This structural increase is the result of several interdependent factors. First, the aging of the existing nuclear fleet has led to increased maintenance and life extension costs for facilities. Enhanced safety programs and extensive inspections have increased the overall cost of operating the electricity system. Second, the development of renewable energies, although characterized by low marginal production costs, requires significant investment in infrastructure and transmission and distribution networks. These massive costs are partially reflected in the final price of electricity. In addition, stricter environmental standards and investments related to security of supply have contributed to the increase in the fixed costs of the electricity system, putting a lasting strain on prices. The growing integration of the French market into the European electricity market exposes France to the upward trends observed in its neighbors, even when the domestic situation is relatively stable, which then impacts prices. Finally, taxes and contributions included in the price of electricity contribute to this structural increase by financing energy transition policies and network infrastructure.

3.2 Acceleration of the increase over the period 2020-2022

The period [2020-2022] is characterized by a marked acceleration in the increase in electricity prices, resulting from a succession of economic shocks. During the Covid-19 pandemic, global economic activity slowed sharply due to the restrictive measures put in place, leading to a temporary collapse in electricity demand, particularly from the industrial sector. From 2021-2022 onwards, the gradual emergence from the health crisis was accompanied by a rapid recovery in economic activity, while electricity production was unable to adjust at the same pace. This rigidity in supply was due in particular to the exceptional unavailability of France's nuclear power plants, linked to the discovery of corrosion and the accumulation of heavy maintenance work in nuclear power plants. The sharp reduction in controllable supply forced France to import electricity on a massive scale, exposing it fully to the European marginal price, which is largely indexed to the cost of gas. The economic recovery thus contributed to more general energy price inflation, exerting strong upward pressure on electricity prices.

3.3 Role of the war in Ukraine: 2022-2024

The war in Ukraine, which broke out in 2022, acted as a catalyst for energy inflation. The gradual reduction in Russian gas flows, followed by the sabotage of the Nord Stream 1 and 2 gas pipelines, led to a lasting loss of gas import capacity for Europe, profoundly changing market expectations. Given the central role of gas in determining the marginal price of electricity on the European market, this supply shock affected all interconnected countries, including France. The latter was particularly exposed due to its exceptional reliance on electricity imports to compensate for the decline in its nuclear production.

3.4 Mitigation and gradual decline in prices 2024-2025

However, this price increase was partially limited, smoothed over time, and then mitigated for several reasons. In France, the *Tarif Bleu* and the *Bouclier Tarifaire* helped limit the surge in market prices for end consumers. In addition, the gradual recommissioning of nuclear reactors led to a recovery in low marginal cost electricity production capacity, reducing exposure to European markets. Furthermore, with most of the investments in renewable energies now completed, the increase in their production has lowered the price of electricity. Finally, at the European level, the diversification of gas supply sources, particularly through the development of liquefied natural gas imports, has helped to increase the available gas supply. This increase in supply has led to a fall in gas prices and, consequently, in electricity prices, including in France. However, our results should be viewed with caution, as mentioned earlier, as the explanatory power of our model remains limited for various reasons.

4 Empirical Strategy

4.1 Data

We collected data on consumption and prices for electricity, wood, fuel oil, and gas via the Data and Statistical Studies Service (SDES), a ministerial department responsible for energy, transport, housing, and the environment. We were also able to obtain data on production by type of facility (nuclear, solar, wind, hydroelectric) in order to calculate the share of electricity produced by renewable energy facilities. Our study covers the period [2007-2025], with monthly observations, and we used inflation data provided by the Bank of France.

Table 1: Descriptive statistics of variables

Variable	**Obs.**	**Min**	**Median**	**Mean**	**Max**	**SD**
$Elec\_Price_{t-1}$	204	11.07420	16.32055	15.97211	25.19210	3.44451
$Price\_Wood_t$	204	207.16000	263.25000	278.76958	609.55000	78.89985
$Price\_Gas_t$	204	5.283000	7.203700	7.338415	12.327500	1.568201
$Inflation_t$	204	-0.800000	1.400000	1.875980	7.300000	1.758123
$Part\_ER_t$	204	0.0323245	0.0680143	0.0723809	0.1387526	0.0241619

4.2 Econometrics Model

To test our hypothesis, we drew on the work of Cerqueira and Pereira da Silva (2017), with the difference that we used a simple time series regression model that focuses on the link between changes in the price of electricity and changes in the share of electricity produced by renewable energy production facilities. We estimate the following model:

$$Elec\_Price_t = \alpha + \beta_{1t} Part\_ER_t + \beta_{it} X_t + \epsilon_t \tag{1}$$

Where, $Elec\_Price_t$ represents the price of electricity at t, $Part\_ER_t$ represents the share of electricity produced by renewable energy production facilities (the variable is equal to the ratio between the sum of all renewable electricity production facilities (wind, solar, and hydro) and total energy production (we add the share produced by nuclear power).

Our control variable matrix X contains, as suggested by Cerqueira and Pereira da Silva (2017), the prices of gas: $Price\_Gaz_t$ (in € per MWh), wood: $Price\_Wood_t$ (in € per MWh) and gas: $Price\_Gaz_t$ (in € per MWh), as well as the variation in inflation: $Inflation_t$ (in %). We also consider the price of electricity in $t-1$, $Elec\_Price_{t-1}$.

$$\begin{aligned} Elec\_Price_t = \alpha + \beta_{1t} Part\_ER_t + \beta_{2t} Price\_Gas_t + \beta_{3t} Price\_Wood_t \\ + \beta_{4t} Inflation_t + \beta_{5t} Elec\_Price_{t-1} + \epsilon_t \end{aligned} \tag{2}$$

4.3 Econometric concerns related to time series

The series of prices for electricity and different energy sources are likely to exhibit temporal trends, which can lead to spurious regressions. Augmented Dickey–Fuller (ADF) unit root tests indicate that the series are non-stationary in level but stationary in first difference. The analysis is therefore conducted on price variations rather than levels. This allows us to capture short-term adjustments in electricity prices to variations in explanatory variables.

Furthermore, Ljung–Box tests applied to the regression residuals reveal the presence of autocorrelation, suggesting that the time dynamics are not fully captured by the model specification. In order to take this autocorrelation into account, as well as the potential heteroscedasticity of the residuals, the statistical inference is based on robust Newey–West standard errors. This correction allows for valid significance tests without changing the estimated coefficients. The results presented in the following section should therefore be interpreted as average short-term effects.

5 Results

Table 2: Ordinary least squares (OLS) regression results without Newey-West correction

	Coefficient	Standard error	t-statistic	p-value
Intercept	16.764	0.311	53.923	$< 0.001^{*}$
$Part\_ER_t$	10.397	25.171	0.413	0.680
$Elec\_Price_{t-1}$	1.567	0.816	1.921	0.056^{*}
$Wood\_Price_t$	-0.020	0.020	-1.032	0.303
Gas_Price_t	2.231	1.122	1.989	0.048^{**}
$Inflation_t$	-1.361	0.895	-1.520	0.130
Observations	220			
R^2	0.043			
Adjusted R^2	0.021			
F statistic	1.936			
p-value (F test)	0.0896			

Notes: The symbols *, **, and *** refer to significance thresholds of 10%, 5%, and 1%, respectively.

Table 3: Ordinary least squares (OLS) regression results
with Newey-West correction

	Coefficient	Standard error	t-statistic	p-value
Intercept	16.764	0.311	53.923	$< 2e-16^{*}$
$Part\_ER_t$	10.397	25.171	0.413	0.41216
$Elec\_Price_{t-1}$	1.567	0.816	1.921	0.24860
$Wood\_Price_t$	-0.020	0.020	-1.032	0.42118
Gas_Price_t	2.231	1.122	1.989	0.04739*
$Inflation_t$	-1.361	0.895	-1.520	0.43119
Observations	220			
R^2	0.043			
Adjusted R^2	0.021			
F statistic	1.936			
p-value (F test)	0.0896			

Notes: The symbols *, **, and *** refer to significance thresholds of 10%, 5%, and 1%, respectively.

The variable of interest in our model, $Part\_ER_t$, does not have a statistically significant effect. This suggests that, over the period studied, variations in the share of electricity produced by renewable energy sources do not have a significant effect on variations in the price of electricity. Thus, the initial hypothesis is not verified by our model. Among the control variables, only the variable representing the price of gas (Gas_Price_t) has a significant and positive impact on changes in the price of electricity. This result is consistent with the literature, as gas plays a major role in the formation of electricity prices. All other control variables have no significant effect. Finally, the explanatory power of our model remains limited: the R^2 and the overall significance test (Fisher's test) show that a large part of the dynamics of electricity price variation is explained by factors that are not taken into account by our model. However, these results should be interpreted with caution, given the model's low explanatory power and the possibility of delayed effects.

6 Conclusion

The aim of this study was to empirically analyze the impact of the share of renewable energies in the electricity mix on the evolution of electricity prices in France over the period [2007-2025]. Using monthly data and a time series econometric approach, we sought to determine whether the share of renewable energies in the French energy mix had a significant impact on electricity prices.

The results indicate that the variable of interest, $Part\_ER_t$, does not have a statistically significant effect on electricity price variations in France over the period studied, unlike the control variable Gas_Price_t, which has a significant and positive impact. These results can be explained by France's gradual integration into the European electricity market.

In this context, the wholesale electricity price is determined by the marginal power plant called upon to meet demand, in accordance with the *merit order* principle. However, during periods of high electricity demand, it is generally gas-fired power plants that are in a marginal position and set the market price. Consequently, even in a country such as France, where the electricity mix is dominated by technologies with low marginal costs, the formation of electricity prices remains strongly influenced by the price of gas.

Nevertheless, it should be noted that these results are based on a model whose explanatory power remains limited. Furthermore, this study focuses on a single country, which limits the generalizability of the results obtained and suggests that the lessons learned from the European literature cannot simply be transposed to the French case. Future work could therefore draw on more sophisticated econometric approaches, incorporating higher-frequency data or international comparisons, in order to deepen the analysis of electricity price formation mechanisms in a context of energy transition and increasing integration of European markets.

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