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## **European carbon prices: what impact on electricity prices in France?**

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Overview topic and backgroundThe anthropogenic nature of GHG emissions is now accepted. Standards, taxes and markets: economists put forward a variety of instruments to fight against climate warming. In 1997, the Kyoto Protocol institutionalized market instruments to tackle climate change. A market for emissions permits would offer several advantages. It would provide a price signal to economic agents, which would be the best way to ensure effective decentralized decision-making for the energy transition. In a quantitatively constrained system of quotas, it would also enable pollution control efforts to be shared out, minimizing the collective costs of reducing emissions (Crocker 1966, Dales 1968, Montgomery 1972).

In 2005, the European Commission created the first binding carbon market (De Perthuis 2008). The European Emission Trading System (EU-ETS) is a market for tradable emissions permits that sets national caps on CO<sub>2</sub> emissions (Gollier & Tirole, 2015), divided between different installations. For each, carbon quota holders must arbitrate between investing in clean production modes, buying quotas on the EU ETS to ensure compliance, or holding them for a later period.

From the outset, the power generation sector received the majority of allocations (Cartel et al. 2017). This production emits a significant amount of CO<sub>2</sub>, which varies according to the quantity produced and the fuel used. We also note that electricity prices now include European capacities, which are part of the interconnected grid. In this context, European prices are still largely dependent on the price of fossil fuels, which play a major role in national power mixes, but also on the price of carbon.

French electricity prices are linked to the European electricity market, and therefore to the electricity mixes of the other countries in the zone. This is why, despite a highly decarbonized energy mix, the question of its potential sensitivity to the EU ETS price signal is open. With European interconnection, the price of allowances on the EU-ETS market could be reflected in the price of French electricity, and in its expectations on futures markets. If this were the case, then the highly institutional nature of the electricity and carbon markets would have enabled price formation, capable of supporting the decarbonization of European electricity mixes, wherever the electrons are consumed.

### Empirical strategy

In order to address the importance of the carbon price in determining the wholesale price of electricity in France, this proposal analyzes the impact of the carbon price on the instantaneous and anticipated price of electricity in France, in relation to various reforms of the EU-ETS market in a given economic context. The period from 1/01/2017 to 12/31/2023 we use

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combines i) a sharp increase in the price of French electricity and European carbon from 2021 onwards ii) the introduction of the Market Stability Reserve in 2019 which, by significantly reducing the supply of allowances, has led to an increase in their price iii) a rapid and unprecedented increase in the price of gas due to Russia's invasion of Ukraine iv) an atypical period of electricity imports for France from European countries. The end of the reference period marks the turnaround in gas prices and a return to normal for electricity production in France.

We use daily data on spot electricity prices in France, electricity production in France mainly from nuclear technologies and French electricity demand. To take expectations into account, we will use market data on futures TTF gas price and price of emissions permits (EU ETS).

Our empirical model is written as follows:

$$\text{Spot Price FR SA} = \beta_0 + \beta_1 \text{NuclearSA}_t + \beta_2 \text{Elec ConsoSA}_t + \beta_3 \Delta \text{TTFY}_{t+1} + \beta_4 \Delta \text{CO}_2 \text{Y}_{t+1} + \epsilon_t \quad (1)$$

In order to test the dynamics of the relationships that may exist between our variable of interest (spot price of electricity in France) and the other variables mentioned, we use cointegration theory and VAR modeling.

### Structure of the proposal and results

Based on a brief overview of the literature on the effects of carbon prices on electricity prices (I) and a review of the various EU ETS reforms to analyze the evolution of their links (II), we suggest that the literature struggles to specify the effects of European carbon prices on electricity prices. These reviews, however, enables us to select an appropriate approach for modeling the impact of carbon prices on electricity prices, as well as well as on futures (III). In the context studied, the influence of the carbon price on the electricity price in France constitutes our main result (IV): with the implementation of the stability reserve from 2019, the increase in the permits prices caused a priority call for gas power plants over coal power plants in the merit order curve. As a result, we saw a much higher equilibrium price of electricity. This upward impact of the TTF gas price on the spot price of electricity was exacerbated following Russia's invasion of Ukraine in February 2022.

As long as gas remains the equilibrium energy resource in the formation of the price of electricity, the price of carbon seems to have become a suitable vehicle for decarbonizing electricity. However, it is crucial to acknowledge that substantial alterations in the energy price dynamics, particularly those affecting the competitiveness of gas relative to alternatives like coal, could diminish the role of the carbon price in driving effective decarbonization strategies

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