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A hybrid Cournot-linear supply function equilibria of coupled electricity and hydrogen markets: An equivalent optimization approach

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Abstract-

Hydrogen is becoming a key energy carrier in the transition toward decarbonization, as electrolysis creates strong interdependencies between electricity and hydrogen markets. Accurately representing strategic behaviour in these coupled markets is essential, yet current models fail to capture price-responsive bidding. To address this, a joint hybrid Cournot-Linear Supply Function Equilibria (CLSFE) model is developed and reformulated as an equivalent optimization problem, enabling tractable large-scale analysis. The model is applied to the Iberian system for 2030 and compared with perfect competition and Cournot benchmarks. Results show that hydrogen prices are lowest under CLSFE, with a reduction of about 44% relative to perfect competition and 10% to Cournot, while hydrogen demand increases by up to 58%. Electrolytic hydrogen production rises up to 92%, displacing grey hydrogen and reducing hydrogen-sector emissions. However, renewable self-curtailment reaches 82 TWh, indicating increased market power. These results highlight cross-sector trade-offs and support market design and policy analysis.

Index Terms- Electricity and hydrogen markets; Sector coupling; Supply functions; Nash equilibrium; Linear programming

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