International Journal of Electrical Power & Energy Systems, vol.170, pp.110902-1-110902-12, September, 2025.

Interactions between electricity and hydrogen markets: A bi-level equilibrium approach

L.J. Fernández Palomino; E. Centeno Hernáez; S. Wogrin

Abstract-

Energy systems increasingly rely on the synergistic operations of the electricity and hydrogen markets pursuing decarbonization. In this context, it is necessary to develop tools capable of representing the interactions between these two markets to understand the role of hydrogen as an energy vector. This paper introduces a bi-level optimization model that captures the interactions between the electricity and hydrogen markets, positioning hydrogen generators as strategic electricity price makers in the power market. The model can be efficiently solved and applied to real-world scenarios by reformulating it as a Mixed Integer Linear Program. The case studies analyze spot market behaviors when hydrogen generators are modeled as price makers in the electricity market. First, single-period simulations reveal the effects of price-making, and next, a year-long simulation assesses broader implications. The findings demonstrate that conventional modeling assumptions, such as the price-taker hydrogen generators in the electricity market and constant production cost hypothesis, lead to non-optimal hydrogen generation strategies that raise electricity prices while reducing the profit of hydrogen generators and the hydrogen market social welfare. These results highlight the need for models that accurately reflect the interdependencies between these two energy markets.

Index Terms- Bi-level program; Generalized nash equilibrium; Hydrogen market; Electricity market; Market coupling; Power systems; Stackelberg game; Strategic bidding

Citation:
Fernández, L.J.; Centeno, E.; Wogrin, S. "Interactions between electricity and hydrogen markets: A bi-level equilibrium approach", International Journal of

Electrical Power & Energy Systems, vol.170, pp.110902-1-110902-12, September, 2025.