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Modifying electricity price signals for incentivizing flexible grid-supplied hydrogen production.

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Extended Abstract

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Abstract Summary

Low electricity prices are pivotal for cost-competitive electrolytic hydrogen (H2) production, while power systems with increasing shares of variable renewable energy require additional demand-side flexibility. A regulatory instrument for grid-supplied electrolysis is developed and evaluated that aims to incentivize flexible consumption through a modified electricity price signal. The modification applies a two-step transformation to the day-ahead spot price: First, the mean is shifted relative to the original annual average. Second, the electricity price is scaled hourly by an amplification factor. This creates synthetic price profiles with higher temporal variation. Using a modified electricity price time series for the year 2024, the levelized cost and life-cycle greenhouse gas emissions (GHG emissions) of the produced H_2 are analyzed. Annual price signals for 2019–2023 are used to assess impacts in different years. Results indicate that stronger price amplification reduces economically viable operating periods. The electrolyzer runtime decreases while increasing responsiveness to low-price hours. Higher price volatility through the instrument lowers the GHG intensity of produced H_2. Lower flexibility factors increase operating hours and weaken incentives for flexible operation. Across years and scenarios, the costs incurred by the instrument to incentivize operators to achieve levelized cost of hydrogen production of €4.0/kg H_2 range from €1.48 to €6.64 per kg H_2 (ranging of approx. 6,000 to 1,500 full load hours). Inflexible baseline operation yields approximately 18,72 kg CO_2-eq per kg H_2, while flexible dispatch reduces emissions to a minimum of 12.83 kg CO_2-eq per kg H_2. EU-compliant low-carbon fuel (LCF) qualification of the H2 produced is not achieved during the period under consideration due to reliance on grid electricity in Germany. The results highlight the trade-off between cost subdsidies and emissions outcomes when using price-based regulation to induce flexible grid-connected electrolysis. Other modification algorithms can be investigated.