WILL HYDROGEN BE SCARCE OR JUST EXPENSIVE? A FUNDAMENTAL ANALYSIS OF THE SENSITIVITY OF HYDROGEN PRICES TO DEMAND

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Overview

The literature often regards renewable hydrogen as a scarce commodity, recommending its prioritized use for specific applications (cf. Ueckerdt et al., 2021). However, hydrogen cost potential curves suggest relatively flat increases and significant electricity availability for electrolysis in the international context (cf. Franzmann et al., 2023). This study evaluates how two opposing factors influence the hydrogen market: first, the price-reducing effects of increased demand through electrolyzer learning curves, and second, the price-increasing effects of sourcing renewable electricity from increasingly less favorable locations as demand grows. The analysis employs a fundamental equilibrium market model spanning Europe and the MENA region.

Methods

The fundamental equilibrium market model minimizes the costs of meeting hydrogen demand across 54 countries, each represented by a single node. It accounts for costs from renewable electricity supply, electrolyzer capacity expansion, and hydrogen transport via pipelines between neighboring countries. The model derives the costs for renewable electricity from cost potential curves for wind and photovoltaic energy. In each of the four scenarios, hydrogen demand increases over time. The scenarios furthermore vary in terms of the per-country hydrogen demand in the same year. While the first scenario considers hydrogen only from applications that are impossible to electrify due to its need as a reactant, reductant, seasonal storage or for aviation and shipping, the other scenarios consider further hydrogen demands from other applications, e.g. high-temperature heat over other uses in the transport sector to low-temperature heating in buildings, with the diffusion of thr respective technologies varying across scenarios. The electrolyzer capacities the model determines for a scenario in a certain year determine the increase in electrolyzer efficiency and reduction in its specific investment for the following year. For electrolyzer improvement in efficiency, a learning rate of 3 %, and for the reduction in specific investment, a learning reate of 18 % is assumed in line with the literature (cf. Bühler & Möst, 2024, Rezaei et al., 2024).

Results

An intermediate version of the model has been run for this abstract for the scenario of the demand arising solely from defossilization measures with no direct electrification option. Despite the in comparison to the other scenarios low demands for hydrogen, the results show considerable effects on the specific investment and efficiency of electrolyzers. The electrolyzer capacity expanded to cover hydrogen demand recudes the initial specific investment of electrolzers of €737 per kW in 2030 to €313 per kW in 2030 and its efficiency increases from 66 % to 75 % in the same period. Further results will be provided at the conference. The other scenarios need to be run and model outcomes to be checked to better derive the implications of how hydrogen prices react to different hydrogen demands.

Conclusions

Hydrogen's role in defossilization remains uncertain, with future demand in the European Union projected between 500 and 5,000 TWh (cf. European Hydrogen Observatory, 2023). The author expects that the scenario results will show a significant effect of hydrogen demand on hydrogen prices. If increased demand raises prices substantially, prioritizing hydrogen for applications inaccessible to direct electrification would be advisable. Conversely, negligible or decreasing price impacts would support early adoption of hydrogen-based defossilization solutions, even for applications where operators have the willingness to pay for hydrogen but could also rely on alternatives such as direct electrification. Stakeholders operating processes inaccessible to direct electrification could then, in the case of an early market run-up of hydrogen, not only benefit from an established market but also from reduced hydrogen prices.

References

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