The impact of white hydrogen on future energy systems

Exploring a deeply uncertain energy system with System Dynamics

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Abstract

Introduction: Renewable hydrogen has emerged as an alternative energy source to achieve low-carbon operations. Recent discoveries of naturally occurring "white hydrogen" deposits might be a game-changer. White hydrogen could rival fossil fuels in cost. However, the global extent of such reserves remains uncertain, and the potential impact of white hydrogen on the global energy system is quantitatively unexplored.

Methods: We explore the potential impact of white hydrogen on the global energy system with an SD model. We run the model for 100,000 different exogenous scenarios to account for the parametric uncertainties associated with white hydrogen. With behaviour-based scenario discovery, we identified archetypical dynamics across the scenario ensemble and their conditions for occurring.

Results: Results indicate that in all scenarios where white hydrogen is economically competitive, its share in the energy mix is substantial by 2050. White hydrogen demand often rapidly develops due to low costs, benefiting from existing gas extraction technology. Additionally, green hydrogen becomes more competitive over time as prices steadily decrease. In most scenarios, white hydrogen becomes the dominant hydrogen type on the market.

Discussion: White hydrogen has a high potential for replacing fossil fuels within the global energy mix, thus reducing global carbon emissions. It could, however, hinder green hydrogen development. Further research on white hydrogen's availability and competitiveness is needed to assess its impact. Additionally, implementing the electricity market and energy infrastructure within the SD model structure will provide more insights into the potential of white hydrogen in aiding the energy transition.

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