A 3D Multiphase Flow Model of Hydrogen Storage in Geological Formations

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Abstract

Renewable energies generate temporary mismatches between energy demand and supply. The conversion of surplus energy to hydrogen and its storage in geological formations is one option to balance this energy gap. Storage in deep saline aquifers is the most cost-effective option for underground hydrogen storage (Lord et al., 2014).
A 3D multiphase flow model in a dome shaped geological formation is built to evaluate the feasibility of seasonal storage of hydrogen produced from wind power in a saline aquifer in Castilla-León region (northern Spain). Due to the low solubility of hydrogen in water (Kolev, 2007), an immiscible formulation of hydrogen gas and liquid water has been implemented in COMSOL Multiphysics® using the Coefficient Form PDE interface.
Three years of operation are simulated after the injection of cushion gas. Hydrogen is injected during 243 days (from October to May) and extracted during 122 days (from June to September). The injection is distributed along a vertical 40 -long well located at the top of the dome, below the impervious caprock and 500 m below the ground surface.
The efficiency of different extraction well configurations during the three injection-production cycles is evaluated (Sainz-Garcia et al., 2017). A maximum hydrogen recovery ratio of 78% is estimated, which represents a global energy efficiency of 30%. Hydrogen upconing emerges as the major risk on saline aquifer storage. Shallow extraction wells can minimize its effects. Steeply dipping geological structures are key for an efficient hydrogen storage.

References:

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