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UNDERGROUND HYDROGEN STORAGE: STOCHASTIC COST-BENEFIT ANALYSIS OF STORAGE MODES, GENERATION METHODS, INFRASTRUCTURE DEVELOPMENT, AND SUBSIDY SUPPORT

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Abstract

Hydrogen storage in subsurface containers such as salt caverns would facilitate wide-scale dispatch of hydrogen for power generation, transportation, residential services, and industrial feedstock. This conceptual storage underpins the Hydrogen Economy, but cost competition with preexisting fossil fuel infrastructure has prohibited hydrogen-based applications from experiencing wider deployment to date. This work explores the costs of each stage of a hydrogen-based supply chain with special focus on domal and bedded salt cavern storage. Other storage modes considered are lined hard rock caverns and depleted oil and gas fields, which are compared on the basis of containment assurance and cost considerations.

A critical review of underground hydrogen storage is included and suggestions for future research directions are presented. We consider various hydrogen production and storage from a cost perspective, in particular hydrogen and ammonia from renewable electricity. The total stochastic cost-benefit model is then modified to show increased hydrogen penetration for various subsidy levels. Results are quantified using net present value and internal rates of return for each scenario.

We show that for subsidy levels similar to what other renewable energy technologies have experienced in the past, hydrogen-based applications will experience appreciable increases in deployment throughout the 21st century energy transition. This work also highlights the importance of domal and bedded salt cavern storage as the lowest cost containers with the highest degree of containment assurance. We suggest that future studies exploring hydrogen diffusion into salt cavern walls, shale and clay rheology during hydrogen transport and storage in bedded salt caverns, considerations for cavern conversion from petroleum products to hydrogen storage, and geomechanical stability of bedded salt caverns represent critical areas of research to de-risk future storage inventories and increase public support for cavern storage.

Keywords: Caverns for Gas Storage, Caverns for Liquid Storage, Bedded Salt Deposits