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Technical Conference Paper

Risk Assessment for Hydrogen Storage in Salt Cavern

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Abstract

As part of the energy transition necessary to combat climate change, France has prioritized the development of a "green" hydrogen industry. Hydrogen, which can be produced from renewable or low-carbon electricity, is an alternative energy vector to fossil fuels. Its potential applications include use in the chemical industry, injection into the gas network, mobility, conversion into methane from CO_2, and conversion into electricity. Due to the intermittent nature of renewable energies, developing a hydrogen sector necessitates safe, large-scale storage solutions, with the underground environment being particularly suitable for this purpose, see Peterse et al. (2024).

The HyPSTER and FrHyGe projects, led by Storengy and supported by the Clean Hydrogen Partnership (CHP) of the European Union, are key initiatives in France focused on advancing underground green hydrogen storage in salt caverns. The HyPSTER project (2021-2025), with a budget of €15.5 million, is centered on feasibility studies and hydrogen-tightness testing of a small salt cavern (~8000 m^3, 2 to 3 metric tons of hydrogen) in Bresse Vallons, aiming to create a scalable storage model for Europe (Grange et al., 2023). In contrast, the FrHyGe project (2024-2028) in Manosque, with a budget of €43 million, aims to demonstrate the storage and cycling of 100 metric tons of hydrogen across two bigger caverns (caverns GA and GB could store 6000 metric tons of in the future), establishing Manosque as a critical hub for hydrogen storage in Europe. Both projects are vital for pushing the boundaries of hydrogen storage technology and enhancing Europe's hydrogen economy.

This paper presents a comprehensive risk assessment framework for hydrogen storage in salt caverns, a critical component in developing large-scale hydrogen infrastructure. The study begins with an overview of existing hydrogen storage facilities in salt caverns, focusing on recent projects in France, Europe, and North America. Key risks associated with hydrogen storage, including leakage, hydrogen embrittlement, and domino effects, are identified and analyzed. The paper then outlines a detailed risk assessment framework and modeling approaches, incorporating scenarios for hydrogen circuits. The assessment includes a rigorous evaluation of gas dispersion (worst case scenario, i.e., well blowout, see Djizanne et al., 2014, 2022a, b), consequence analysis, and the performance of safety barriers under various hazardous conditions, such as flash fires, unconfined vapor cloud explosions (UVCE), and jet fires. A comparison is made between the behavior of hydrogen and that of natural gas. The findings underscore the importance of robust safety measures and advanced modeling techniques to predict and mitigate the risks associated with Underground Hydrogen Storage. This research contributes to the development of safer and more reliable hydrogen storage systems, which are essential for the transition to a sustainable energy future.

Keywords: Energy transition, Underground Hydrogen Storage, salt caverns, risk assessment, safety, blowout, gas dispersion.

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