LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI

GTI ENERGY

EXECUTIVE SUMMARY

MODELS FOR UNDERGROUND STORAGE OF HYDROGEN

Daily and Seasonal Hydrogen Storage in Depleted Natural Gas Reservoirs—Selected Topics

PRIMARY AUDIENCE: Prospective owners/operators of underground hydrogen storage facilities

SECONDARY AUDIENCE: EPRI members and geoscientists

KEY RESEARCH QUESTION

The storage of hydrogen (or a hydrogen-methane blend) in a depleted natural gas reservoir raises questions about the robustness of the calculated storage performance with respect to uncertainties in reservoir properties, storage integrity (for economic and safety reasons), the feasibility and optimization of injection-withdrawal operations, upconing during the withdrawal phase, and issues regarding the mixing and/or separation of the various gas components. These questions are addressed in this study using numerical simulation.

RESEARCH OVERVIEW

Using the newly developed simulation module iTOUGH2-EOS7CH, a generic model of a depleted natural gas reservoir was developed for the simulation of various daily and seasonal hydrogen storage scenarios. Performance metrics appropriate for each of the study objectives were defined and calculated by the model. The relative impacts of influential reservoir properties and operational parameters were calculated to examine the robustness of the results and their interpretation.

KEY FINDINGS

Key findings from the full report include:

- The details and challenges of hydrogen storage in a repurposed natural gas reservoir depend on the use case.
- Underground hydrogen storage appears feasible for a wide range of reservoir conditions.
- Potentially detrimental processes, such as upconing, methane contamination, spill-point loss, and caprock leakage, can be mitigated by proper site selection and optimization of storage development, well placement, and injection-withdrawal operations.
- Horizontal permeability is the key reservoir property affecting the performance of the storage system, with high values being preferable.
- Low vertical permeability and low initial gas content of the caprock are required to ensure the containment of the hydrogen in the reservoir. If these properties remain similar to those experienced by the natural gas storage industry over the last 100 years, hydrogen leakage rates through the caprock are expected to be small.
- Upconing of water or cushion gas into the withdrawal well is predictable and can be mitigated by proper site selection, well design, and cyclic injection-withdrawal operations that reduce upconing.

- The component fractions of a blend of hydrogen and methane injected into a porous-medium storage reservoir remain essentially constant in the reservoir: that is, no significant gas separation occurs due to gravity sedimentation or thermodiffusion.
- The iTOUGH2-EOS7CH simulation-optimization software is capable of predicting the evolution of a hydrogen storage system during repurposing and operation.

WHY THIS MATTERS

Understanding and predicting processes occurring in a hydrogen or blended hydrogen-methane storage reservoir is essential to assessing the technical viability of this technology. This is especially true for repurposed natural gas storage systems and for the development of hydrogen storage in depleted natural gas reservoirs. Concerns about hydrogen leakage, upconing, and gas separation are addressed, and recommendations regarding the mitigation of these concerns are provided.

HOW TO APPLY THE RESULTS

The implementation of various use cases into simplified, generic reservoir models, as well as the related simulation and sensitivity analysis approaches presented in this report, can be used as the basis for simulating and evaluating potential site-specific hydrogen storage systems. The sensitivity analyses presented in the report can be extended by including additional parameters and evaluating different performance metrics.

LEARNING AND ENGAGEMENT OPPORTUNITIES

Short courses on the usage of the iTOUGH2 simulation-optimization software package are offered by the Lawrence Berkeley National Laboratory (https://tough.lbl.gov/events/tough-short-courses/#iTOUGH2) and Finsterle GeoConsulting, LLC (https://www.finsterle-geoconsulting.com/training).

The Low-Carbon Resources Initiative

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of EPRI and GTI Energy addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit www.LowCarbonLCRI.com.

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3002028475 November 2023

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