Sensitivity Analysis and Simulation of Underground Hydrogen Storage in the Lehen Field, Upper Austria

M. Abdellatif[1], S. Azizmohammadi[1], G. Stiedl[1], P. Jasek[1], H. Ott[1], M. Pichler[2]
[1]Montanuniversität Leoben, Department Geoenergy, Leoben, Austria, [2]RAG Austria, Subsurface Storage Development, Vienna, Austria

Enormous storage capacity of excess renewable energy is required to accommodate the misalignment between time-dependent energy consumption and fluctuations in energy supply. Gas as an energy carrier, can be stored in such large amounts in subsurface structures of depleted hydrocarbon reservoirs. Especially hydrogen gas has been identified as an excellent energy carrier and can be produced from the surplus of renewable energy. Several geological reservoirs (aquifers, salt caverns, and depleted gas reservoirs) can be utilized for that purpose, yet storing hydrogen in subsurface structures is challenging due to its distinctive physical, chemical, and biochemical behaviors. Hydrogen is highly diffusive which would boost its total dispersion into the reservoir. Additionally, the susceptibility of hydrogen to microbial activity could contribute to potential losses due to microbial conversion processes such as methane production via methanogenic archaea or acetate via acetogenic bacteria. These challenges in turn complicate the modeling process of underground hydrogen storage. Despite the high interest in storing hydrogen in depleted gas reservoirs, globally a sparse number of projects have reached the pilot project scale. In association with its partners, RAG Austria AG developed the Underground Sun Storage project as one of the leading projects to investigate large-volume seasonal storage of hydrogen and hydrogen admixtures.

In this study, we used the data from this project to examine the different parameters and mechanisms that control the modeling results to match the historical observations from the first storage cycle in the pilot field in 2016. Several different scenarios were studied using the model built in CMG. The log data from the well was used to distribute porosity and permeability in vertical direction. Analysis of the bottom hole pressure profile from field observations revealed a pronounced decline during production, which could be attributed to lateral heterogeneity. Due to the lack of petrophysical data, lateral heterogeneity has been modeled by a sink in the reservoir that is simulated through extra production to achieve a history match with the production data. Our findings show that molecular diffusion is responsible for the further migration of hydrogen up to ~4% of the total injected hydrogen into the in-situ gas (natural gas) that originally exists in the reservoir prior to injection. Moreover, simulation results show higher methanation than the field observations due to the fact that zero activation energy was assumed for the methanation reaction which represents the upper limit of methanation in the reservoir. Through a sensitivity analysis, the influence of each parameter on the methanation process was quantified. This study indicates that diffusion and methanation are the main controlling mechanisms. However, the impact of gravity segregation and vertical heterogeneity are minor due to the reservoir thickness.