Hydrogen Storage in a Saline Aquifer within the North German Basin

Tobias B. Weisenberger[1], Maria B. Febbo[1], Wisdom David[1], Lea Döpp[1], Mrityunjay Singh[1], Anna-Maria Eckel[1], Juliane Kummerow[1], Peter Pilz[1], Cornelia Schmidt-Hattenberger[1], Ingo Sass[1]

[1]Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences

Abstract

Hydrogen is a key low-carbon energy carrier that is attracting global attention for energy storage to mitigate the main drawbacks of renewable energy generation, their intermittency and their seasonal and geographical constraints. Renewable energy sources are greatly dependent on seasonal fluctuations such as sunlight intensity and wind force. Combined with seasonally varying, but steady, energy demand, results in renewable energy excess or deficit. Hence, renewable energy without energy storage is unable to satisfy the whole system's energy demand. Excess renewable energy can be converted to hydrogen through electrolysis (‘‘green hydrogen’’). Green hydrogen can then be stored and used during periods of high energy demand. In contrast to hydrogen storage in salt caverns, underground hydrogen storage in porous media remains largely untested.

The Helmholtz funded GEOZeit project aims to establish one of the first hydrogen solely underground storage demonstrator within a saline aquifer. The North German Basin and the well constrained stratigraphic inventory and structural setting mark an ideal place to establish a hydrogen demonstrator in a porous medium located saline aquifer. In preparation for the demonstrator project, the HyPrepare phase within the GEOZeit project allows for a systematic characterization and evaluation of a suitable demonstrator location in the North German Basin that will enable safe cyclic storage of hydrogen. Existing knowledge of previous underground storage within the North German Basin, such as town gas or CO2 represents a foundation, which is further elaborated and adapted for hydrogen. Structure traps in the North German Basin, such as anticline structure related to salt diapirism, permeable sandstone within the Mesozoic strata and multiple claystones through the stratigraphy that act as multi barriers form suitable conditions for a hydrogen subsurface storage demonstrator. Site specific investigation are carried out in order to plan and design cyclic hydrogen storage. This includes, geological investigations and modeling, numeric simulation, and laboratory experiments. These investigations encompass a wide range of mechanisms from micro- to macroscopic scales. Geological investigations and modeling include detailed work on the extent of permeable horizons suitable for storage as well as claystones. Numerical models play a crucial role in the investigation process, offering insights into the microscale interactions between fluids, rock formations, and microbial activity, as well as macroscale flow dynamics to optimize storage configuration.
Laboratory experiments on representative samples are performed to elaborate the feedback between fluid-rock- microbial interaction during cyclic hydrogen storage on the petrophysical properties of the subsurface lithologies. In addition, experiments are conducted that yield information on the hydrogen diffusivity through the reservoir rock as well as the cap-rock, and quantify the hydrogen solubility within the reservoir brine. Based on the site- specific evaluation a drilling program will be developed, including well design that is compatible with cyclic hydrogen storage.
This paper will present the recent investigations and development towards a hydrogen demonstrator project in the North Germany Basin, focusing on a safe and sustainable operation scenario.