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Storage and Recovery of Hydrogen in Non-Salt Bearing Strata - Deliverability for Power Generation

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Abstract

Salt caverns have been used for hydrogen storage by the chemical and refining sectors in the United States since the 1980s. Salt deposits suitable for hydrogen storage are not widely distributed across the North American continent. The Illinois State Geological Survey (ISGS) along with an industry partner developed a concept design for hydrogen storage in a saline reservoir to augment deliverability to a flexible-fuel gas turbine providing power to a local electrical grid. Assessment of the saline aquifer involves both static geocellular models as well as dynamic simulations of reservoir performance. This includes identification of potential strata for storage (reservoir properties, fluid composition, reservoir pressures); identification of strata to be used as barriers/baffles (caprock analysis including leakage potential/rate); preliminary estimates of hydrogen losses via diffusion, dissolution, potential chemical/microbial hydrogen consumption and storage volume estimates. In the preliminary concept/design phase, a regional sandstone brine aquifer present across the central and northern Illinois basin was characterized for storage. Specific attention was given to working gas performance under short-duration cycles, cushion gas influence on water production, and hydrogen mobility in both lateral and vertical directions. The impact of subsurface well design on near-bore gas saturations for extended injection/withdrawal cycles was investigated. In-reservoir and external containment intervals using relative permeability data allowed preliminary examination of sealing capacity. Modeling on the effect of capillary forces in pore volumes utilizing wettability parameters was incorporated to delineate saturations and hydrogen mobility in the subsurface. Preliminary results were integrated into this demonstration project to test viability of commercial-scale implementation. Lateral perforations into the injection interval preserved higher gas saturations and reduced water production during injection/withdrawal cycles. Relatively thin (10-15’) shale horizons internal to the reservoir provided barriers to vertical movement that prevented migration into the overlying caprock. The addition of capillary forces into the simulation further reduced vertical migration but enhanced the amount of water production during withdrawal. Long-cycle simulations are ongoing with additional modeling of variable cushion gas volumes.