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Compositional simulation of hydrogen storage in a depleted gas field

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UK natural gas demand is 2-4 times that of electricity and characterised by seasonal differences in demand of almost triple in the winter with larger spikes during extreme cold weather events. This makes any decarbonisation effort reliant on its ability to handle these large changes in demand. Conversion of the gas supply to hydrogen is the most promising solution. To facilitate this, large-scale underground storage will be required in the order of 150 TWh or 40 days' worth of supply.

Subsurface gas storage in porous rocks requires a proportion of the gas to remain in the reservoir to maintain the pressure required for the minimum economic flow rate from the wells. This is called the cushion gas requirement. In the case of a hydrogen storage reservoir the use of a cheaper cushion gas, such as CO_2 or N_2, is the subject of much research.

We investigate the possibility of using natural gas within a partially depleted gas reservoir as cushion gas. We will present the results of a compositional simulation of seasonal hydrogen storage over a 20 year period in a closed reservoir. The study shows that natural gas has potential as a cushion gas, in this case achieving greater than 95% hydrogen recovery factors with minimal amounts of mixing in the reservoir. Use of natural gas as cushion gas also reduces the risk of water coning which can lead to loss of hydrogen.

Although these results are promising, the study highlights several key areas that need further investigation to improve the reliability of future simulations. These include defining relative permeability curves for hydrogen, refinement of how simulators handle viscosity equations, and a greater understanding of hydrogen well engineering. All of these factors will influence estimates of the hydrogen capacity of a porous rock reservoir.