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Exploring Hydrogen Storage Strategies in Geological Formations to Minimise Gas Mixing

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Large-scale H_2 storage within porous geological formations – such as depleted hydrocarbon reservoirs – presents a practical opportunity leveraging existing energy industry infrastructure to address renewable energy intermittency (e.g., from wind and solar). H_2 can be generated from excess renewable energy, stored in these reservoirs, and drawn when needed. Depleted gas reservoirs have proven to trap gases (e.g., natural CH_4) over geological timescales, and have been used for large-scale CH_4 storage. The working gas (i.e., H_2) is the fraction that is injected, stored temporarily, and produced from the reservoir. The cushion gas, the share of the injected gas that remains in the reservoir to maintain operational pressures and drive the production, represents an initial investment in the storage operation. Therefore, because H_2 is relatively expensive, the use of a cheaper alternative cushion gas – such as CO_2 and / or in-situ CH_4 – can reduce the investments needed. Furthermore, the use of CO_2 storage can simultaneously contribute to Net-Zero goals (as the CO_2 will remain fixed in the reservoir).

One of the main challenges associated with the use of alternative cushion gases in these storage systems is the mixing with the working gas. Increased mixing will increase the cost of separation after production. In this study, we explore how the mixing of cushion and working gas can be minimised by using the reservoir geometry of laterally extensive reservoirs such as the Southern North Sea gas fields. Ultimately, the reservoir architecture and the infrastructure will dictate the extend of the contact area between the cushion and working gases, and by reducing this, the risk of mixing will be reduced. This work proposes an alternative operational strategy that investigates the storage of H_2 working gas and CO_2 cushion gas in a depleted system, where both gases are kept separated by injecting them at opposing ends of a reservoir to reduce the surface area of the mixing gas interface.