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# Geological modelling and reservoir simulation workflows for hydrogen geostorage in depleted gas fields, Aotearoa New Zealand

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Underground storage of green hydrogen in depleted gas fields could provide Aotearoa New Zealand (ANZ) with a storage option critical for meeting peak energy demands and realising green hydrogen ambitions. During early de-risking of specific sites, it is important to develop an accurate geological model to test whether the reservoir has the desired containment, volume and hydrogen deliverability. However, where seismic reflection lines and well data are limited and/or the storage system is structurally complex, the resulting geological models may be non-unique. Therefore, injection and withdrawal simulations using different structural end members is critical to constrain how a hydrogen plume may flow within (and out of) the container and interact with existing reservoir fluids.

Here we present workflows for modelling a multi-year injection and withdrawal cycle of hydrogen into a depleted gas field. We use data from the Tariki Sandstone Member of the Ahuroa field in the Taranaki Basin, currently used to store natural gas in ANZ. This reservoir is located 2 km deep at the crest of an anticline above a major thrust fault, with marine mudstones forming the top seal and low-permeability fault rock the lateral seal. With only mixed quality 2D seismic reflection lines and a tight well cluster, the precise geometry of the thrust fault and its relations to smaller secondary faults is poorly constrained.

To capture this uncertainty in our simulations, we have developed two 3D geological models of the Ahuroa field in Leapfrog Energy software. We use these geological models to conduct dynamic simulation of hydrogen injection and withdrawal using the massively-parallel simulator PFLOTRAN-OGS. We develop simulations that allow us to, over a 10-year cycle, test for closure or spill into adjacent fields, and predict the amount of mixing with remnant natural gas and formation water. During the simulations, we see major differences between the two geological models related to cushion injection and working $H_2$ volumes, rates of water production and impurities due to natural gas. Additionally, one model has high risks of unrecoverable $H_2$ gas loss when over-pressurised. Finally, we reimport the results back into Leapfrog for visualisation of the behaviour of the two hydrogen plumes over time.