Seasonal storage of hydrogen in porous formations

Katriona Edlmann\(^1\), Niklas Heinemann\(^1\), Leslie Mabon\(^2\), Julien Mouli-Castillo\(^1\), Ali Hassanpouryouzband\(^1\), Ian Butler\(^1\), Eike Thaysen\(^1\), Mark Wilkinson\(^1\), and Stuart Haszeldine\(^1\)

\(^1\)The University of Edinburgh, College of Science and Engineering, School of Geosciences, Edinburgh, United Kingdom of Great Britain and Northern Ireland

\(^2\)Scottish Association for Marine Science, Oban, PA37 1QA, United Kingdom of Great Britain and Northern Ireland

To meet global commitments to reach net-zero carbon emissions by 2050, the energy mix must reduce emissions from fossil fuels and transition to low carbon energy sources. Hydrogen can support this transition by replacing natural gas for heat and power generation, decarbonising transport, and facilitating increased renewable energy by acting as an energy store to balance supply and demand. For the deployment at scale of green hydrogen (produced from renewables) and blue hydrogen (produced from steam reformation of methane) storage at different scales will be required, depending on the supply and demand scenarios. Production of blue hydrogen generates CO\(_2\) as a by-product and requires carbon capture and storage (CCS) for carbon emission mitigation. Near-future blue hydrogen production projects, such as the Acorn project located in Scotland, could require hydrogen storage alongside large-scale CO\(_2\) storage. Green hydrogen storage projects, such as renewable energy storage in rural areas e.g. Orkney in Scotland, will require smaller and more flexible low investment hydrogen storage sites. Our research shows that the required capacity can exist as engineered geological storage reservoirs onshore and offshore UK. We will give an overview of the hydrogen capacity required for the energy transition and assess the associated scales of storage required, where geological storage in porous media will compete with salt cavern storage as well as surface storage such as line packing or tanks.

We will discuss the key aspects and results of subsurface hydrogen storage in porous rocks including the potential reactivity of the brine / hydrogen / rock system along with the efficiency of multiple cycles of hydrogen injection and withdrawal through cushion gasses in porous rocks. We will also discuss societal views on hydrogen storage, exploring how geological hydrogen storage is positioned within the wider context of how hydrogen is produced, and what the place of hydrogen is in a low-carbon society. Based on what some of the key opinion-shapers are saying already, the key considerations for public and stakeholder opinion are less likely to be around risk perception and safety of hydrogen, but focussed on questions like ‘who benefits?’ ‘why do we need hydrogen in a low-carbon society?’ and ‘how can we do this in the public interest and not for the profits of private companies?’

We conclude that underground hydrogen storage in porous rocks can be an essential contributor to the low carbon energy transition.