Subsurface energy storage

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Exajoule $10^{18}$J storage capacity required

Thermal energy in 1 kg hot water: $E = c\Delta T \approx 0.42$ MJ

Energy in 1 kg of nitrogen compressed at 10 MPa: $E = \frac{RT}{m} \ln\left(\frac{P_1}{P_2}\right) \approx 0.41$ MJ

Heat of combustion of 1 kg of hydrogen: $E = \frac{H}{m} \approx 120$ MJ

$10^{18}$ J scale (global energy use is approximately 600 EJ) requires storage at the Gt ($10^{12}$ kg) scale globally: long-term intermittency in renewables. Either store in porous media or engineered salt caverns.

Hematpur et al. Advances in Geo-Energy Research (2023)
Potential for large-scale storage

On track for Gt-scale storage if current growth rates are maintained. No significant technical barriers to widespread implementation. Storage in aquifers and depleted hydrocarbon fields.

Research challenges

Caprock:
- Diffusion
- Capillary leakage
- Fracturing
- Buoyancy pressure

Hydrogen plume:
- Fluid-rock interaction
- Microbial activity
- Dissolution & residual trapping

Injection/production:
- P/T change
- Multiphase processes
- Stress/strain changes

H₂ - cushion gas:
- Unstable displacement & uncontrolled lateral spreading
- Gas mixing

Cushion gas - brine:
- Fluid-rock interaction
- Unstable displacement
- Dissolution & residual trapping

Structural geology:
- Fault leakage
- Far and near field stress changes
- Reactivation
- Overpressure

Inter-linked challenges in the energy transition

Krevor et al. Nature Reviews Earth and Environment (2023)
Net Zero by 2050
Our ambition is to be a net zero company by 2050 or sooner. And to help the world get to net zero. This will mean tackling around 415 million tonnes of emissions – 55 million from our operations and 360 million tonnes from the carbon content of our upstream oil and gas production. Importantly these are absolute reductions, to net zero, which is what the world needs most of all. We are also aiming to cut the carbon intensity of the products we sell by 50% by 2050 or sooner

“The world’s carbon budget is finite and running out fast; we need a rapid transition to net zero”

Bernard Looney, chief executive officer
13th February 2020
A carbon neutral strategy for the oil industry

To commit to be net CO$_2$ neutral by 2050.

To store a volume of CO$_2$ *underground* which is at least as large as the CO$_2$ produced in oilfield operations, refining *and* when the hydrocarbon is burnt.

To lobby governments to make this happen, while informing and engaging with the public.

Major plans in the UK, tax breaks in the US.

Have a commitment to store a percentage of CO$_2$ that rises to 100% by 2050.