Imperial College London

Natural Environment Research Council

2023_34_ESE_Jackson: Developing the world's largest geobattery: ultra-high-temperature underground thermal energy storage for large-scale electricity storage in the UK

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Underground Thermal Energy Storage (UTES) is a type of geothermal energy storage in which warm or hot water is pumped underground and stored until it is required, when it is pumped back to surface. Most UTES deployments store warm water to provide seasonal space heating: excess heat in the summer is stored for use in winter However, water stored at high temperature (ultra-high-temperature UTES) could be used in turbines for electricity generation, offering the potential to store large quantities of electricity in a geobattery.

Preliminary work by the NORMS group at Imperial College suggests that the UK could store several PWh of electrical energy underground in old oil and gas reservoirs and deep saline aquifers. This storage capacity is orders of magnitude larger than conventional storage technologies such as batteries or pumped water storage; for comparison, the 'Big Battery' project in Australia can store 450 GWh and the UK's largest pumped storage facility can store 9 GWh, as compared to UK annual electricity demand of c. 350 TWh. Storage at large scale is essential to buffer imbalances in demand and supply from intermittent renewable energy sources such as wind and solar, which create price instability and risk of power outages. However, despite its potential for large-scale electricity storage, significant uncertainties remain concerning round trip storage efficiency, discharge capacity, the subsurface response to UHT-UTES, and how systems should be optimally engineered.

The aim of this project is to undertake numerical modelling of UHT-UTES in UK reservoirs to underpin the world's first trial UHT-UTES deployment. The project will address research questions which include (i) what is the reservoir response to UHT-UTES; (ii) what are the potential environmental risks, such as seismicity and/or co-production of oil and gas; (iii) what is the round-trip storage efficiency, (iv) what is the discharge capacity, and (v) how should deployments be optimally engineered to safely maximize storage and discharge capacity? Industry partner Equinor offer an enhanced stipend and a 3 month internship that will provide practical industry experience.

The project will involve the use of advanced numerical methods for simulating fluid flow, heat transport and chemical reaction in UHT-UTES systems, combining methods developed and applied by the Novel Reservoir Monitoring, Modelling and Simulation (NORMS) group in the Department of Earth Science and Engineering (ESE). There is also the potential to undertake experiments in the NORMS Laboratory for Reservoir Physics, to measure key reservoir material properties at the storage conditions of interest.

Applicants should hold a degree in a related subject such as geoscience, physics, engineering or mathematics and, ideally, some experience in reservoir or aquifer modelling. Training will be provided as required in specific aspects of the project. The research will deliver fundamental new understanding of UHT-UTES, supporting ongoing research at ICL in geothermal energy.

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