Proposed Studentship

Subsurface reservoirs for chemical storage of electricity

Fully funded, 4-year PhD opportunity

Supervisors: D Waltham (Department of Earth Sciences, Royal Holloway University of London), S Kuenzel (Department of Electrical Engineering, Royal Holloway University of London) and A Basu (Department of Earth Sciences, Royal Holloway University of London)

Project Description:

Flow-batteries are a novel from of rechargeable battery in which chemical energy is stored in fluids (electrolytes) which are external to the battery itself. This is a cheap form of electricity storage but, to be useful for large-scale applications, the electrolyte tanks need to be enormous. The over-arching research question of this project is: can we use subsurface aquafers and/or exhausted hydrocarbon fields instead of tanks?

As an illustration of the possible storage potential, a flow-battery based upon Vanadium Redox reactions stores approximately 20 Wh per litre of electrolyte and, hence, an exhausted billion-barrel oil field would hold 3 TWh of electricity. This is equivalent to 30 weeks' output from a large offshore wind-farm which is far more than is needed to eliminate the intermittency issues associated with such a facility. The wind farm would become a reliable source of continuous electricity; removing the need for back-up supplies from, for example, nuclear or gas-fired generators.

Picture credit: @craigdoesdesign

The idea of using the subsurface to store electrolytes is completely novel and so the technical, environmental and economic barriers to implementation have never been investigated. This project will undertake the first such study. In particular, it will involve:

1. An investigation of the technical feasibility
2. A review of potential UK continental shelf (UKCS) locations

The techniques required will be an extension of geophysical and geochemical approaches already used for evaluation of hydrocarbon fields and mineral deposits. Hence, this project will prepare the student for careers in the Earth-Science-based industries of both the present and the future.

Detailed Workplan:

1. Literature review covering
    i. Subsurface storage of energy
    ii. Reservoir modelling
    iii. Hydrocarbon trapping mechanisms and reservoir compartmentalization
    iv. Geochemical modelling of ionic solutions
    v. Flow batteries

2. Physical properties of reservoirs and seals. How will these influence subsurface electrolyte storage and retrieval? This stage will involve reservoir modelling using standard industry techniques but with densities and viscosities appropriate to electrolytes. Note that organic solvent based electrolytes may be required as these can be less dense than water and can therefore be trapped conventionally. Organic solvents have other chemical, physical and electrochemical advantages too but may have environmental-impact disadvantages.

3. Chemical properties of reservoirs, seals and pore-fluids. How will these interact with different electrolyte systems? This will be investigated using the "Geochemists Workbench" software with much of the work involving modification of the software database to include reaction rates in non-aqueous solutions.

4. Evaluation of a small number of possible UKCS storage locations. The objective is not to undertake an exhaustive review of all possible sites but, rather, to use a few examples to develop the techniques and criteria needed to assess potential reservoirs.

5. Putting it all together. A single location will be chosen and an outline plan developed which estimates the capacity, power and cost of that installation. These results will be compared to those of alternative subsurface energy storage methods as well as to more conventional solutions such as batteries or pumped-water-storage. An initial environmental impact assessment will also be made.

6. Writing up.

Benefits:

This proposal is part of the multi-University, industry-funded Doctoral Training Centre in "The role of Geoscience in facing the low carbon energy transition and the challenge of net-zero". The successful applicant will therefore be on a PhD programme with exceptional benefits including:

- Fees and maintenance fully funded for 4 years.
- Additional £20k of research support funding (e.g. for conference attendance).
- 20 weeks of vocational training and industry links to enhance employability.
- Industry links.

Please contact the lead supervisor directly for further details

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