The Impact of Thermal Plumes on properties of the Sherwood Sandstone Aquifer

Joseph Ireland¹, Dr. Ulrich Ofterdinger², Professor John Barry³
Queen’s University Belfast & University of Aberdeen

Justification

• The global community has to face a just transition towards sustainable energy due to the exponential rise in greenhouse gas emissions and resulting Climate Change impacts.
• In the Special Report (SR1.5) issued by the International Panel on Climate Change (IPCC) in 2018, geothermal energy is listed as one of the forms of renewable energy that can aid in our just transition and green growth.
• SR1.5 details specific climate action mitigation methods. The action relevant to this research is adopting low-emission innovations utilising heat pumps and district heat & cooling (SR1.5, 2018).
• In Northern Ireland, the heating sector represents 50% of the final energy consumption (DfE NI, 2019).
• The City of Belfast in Northern Ireland characterises the highest demand for heating and cooling energy in the country, peaking at > 1500kW/lnm² (DfE, 2019).

What is Aquifer Thermal Energy Storage (ATES)?

- In-situ geophysical characterisation completed, including borehole Magnetic Resonance (BMR).
- Aquifer transmissivity properties analysed from previous pumping and injection test data.
- DfE and DAERA consulted on future ATES projects in NI based on research outcomes.
- Initial FEFLOW model constructed to analyse thermal plume propagation based on in-situ data (Fig. 7).
- Future of Geothermal Energy in Conference held with 320 attendees.

Geological Background

City Centre
Queen’s borehole test site
Belfast
Harbour area

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Geological Background

- The geological of Northern Ireland has a high degree of variation. Hydro-geologically, there are multiple aquifers across the country that represent an opportunity for groundwater development in the form of ATES.
- The most prolific aquifer is the Triassic Sherwood Sandstone (SWS) located in the Belfast area that has a long history as a source of ground water (Fig. 2).
- The aquifer is now only used for private consumption and two small scale inorganic precipitation and secondary mineralisation but also by promoting microbial activity within the aquifer, with the addition of biomass adding to the reduction of aquifer porosities.
- In this turn may affect the overall efficiency and sustainability of the duplet borewell installation and reduce the sustainable yield of the groundwater body for other nearby water supplies.
- The thermal storage performance of the ATES system and heat transport around the wells are likely to be impacted by existing aquifer heterogeneity due to preferential flow paths.
- The thermal storage performance of the ATES system and heat transport around the wells are likely to be impacted in the long term by the “warm well” due to points mentioned in the first consideration.
- The influence of thermal plume temperature ranges on thermal storage performance and aquifer hydraulic properties requires long term borehole site investigation and numerical modelling.

Research Questions

1. What will the impacts be on the hydraulic properties of the Sherwood Sandstone aquifer as a result of storing the thermal plumes in ‘warm wells’?
2. How does variation in temperature of the thermal plume alter the impacts observed on the Sherwood Sandstone aquifer hydraulic properties?
3. What is the thermal storage performance of the Sherwood Sandstone aquifer in the test area?
4. How can ATES be integrated into the future energy matrix for Northern Ireland?

Methodology Considerations

- The thermal plumes discharged into the “warm well” of an ATES system are not only likely to reduce aquifer porosities and permeabilities due to inorganic precipitation and secondary mineralisation but also by promoting microbial activity within the aquifer, with the additional biomass adding to the reduction of aquifer porosities.
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Future ATES Integration

- The Department for Economy are currently drafting a new Northern Ireland Energy Strategy to 2050 & the Department for Agriculture, Environment and Rural Affairs are currently drafting a Climate Change Act for Northern Ireland.
- The aim of this research is to feed into the strategies of both these documents as a future low-emission renewable energy in the heating and cooling sector.
- Additional options for ATES integration into the energy matrix include; storage of waste heat from hydrogen production/ wastewater treatment to then supply this heat energy into a social housing district heating scheme or district heating system poly tunnel project.

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References