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Repurposing a Geothermal Exploration Well as a Deep Borehole Heat Exchanger: Updates from the NetZero GeoRDIE Project

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The Newcastle Science Central Deep Geothermal Borehole (NSCDGB) was drilled to 1821 m between 2011 and 2014, targeting the Mississippian Fell Sandstone Formation as a conventional geothermal resource. Unfortunately, the formation was tight and the wellbore encountered low hydraulic conductivity values of 8.1 x 10^{-10} m/s, preventing development and exploitation (Younger et al., 2016). The NetZero GeoRDIE project investigates the potential to repurpose the NSCDGB as a closed-loop system with the intent of extracting heat from an otherwise unused asset. The project analyses i) the impact of uncertainty in the subsurface through detailed numerical modelling of a coaxial deep borehole heat exchanger (DBHE) on heat abstraction, ii) the capability of the wellbore to provide heating through thermal response testing and monitoring, and iii) the integration of the DBHE to either a heat network or adjacent buildings.

Transient analysis of the subsurface has been undertaken using both numerical and analytical solutions to quantify: how much heat can be extracted, the potential to use the DBHE for underground thermal energy storage, performance under varying methods of operation (i.e., constant heat load, variable heat load) and uncertainty in the subsurface. Results indicate that the borehole repurposed to a depth of ~920 m, with a ground thermal conductivity of 2.55 W/(m.K), can be operated sustainably with thermal extraction rates of 50 kW (flow rate of 5 L/s) for 25 years, supplying a building load of 65 kW after passing through a heat pump (Kolo et al., 2023). Under varying methods of operation, the rate of heat extraction can be improved with short periods of heat reinjection, or if intermittent operation is applied (Brown et al., 2023a,b). Geological variations in the subsurface also impact performance, particularly the natural geothermal gradient, or rock thermal conductivity; however, groundwater flow has a minor impact on heat extraction unless Darcy velocities exceed c. 1 x 10^{-6} m/s (Brown et al., 2023c). Further uncertainty analysis has also been considered to quantify the effect of spatial variability in the subsurface by using surrogate models and stochastic simulations.

At present, the repurposing of the wellbore to recomplete as a coaxial DBHE and undertake a thermal response test is in planning and will hopefully be complete by 2024. This will allow us to measure the in-situ properties of rocks at depth (i.e., thermal conductivity) and the effective borehole thermal resistance. These will allow better estimates on the amount of heat that can be recovered, and allow the calibration of models against empirical data.

Subsurface data can then be integrated to building energy simulation models of the Urban Science Building, which is derived from monitored data of over 4000 sensors. Building energy simulation models are used in predicting heat load under varying global warming scenarios, whilst also allowing thermal comfort and temperature setback strategies to reduce heat demand and CO_2 emissions. Initial uncalibrated numerical models have been used to match demand with geothermal energy supply, highlighting that a DBHE is better suited to meeting a constant base load of energy, rather than a variable heat load. This is because conduction is the dominant method of heat transfer and thus heat cannot be extracted quickly enough to meet the surges in demand in winter for the variable load (Ben et al., 2023).

References

Ben, H., Walker, S., Brown, C., Kolo, I. and Falcone, G., 2023. Decarbonising Heating and Cooling Using Temperature Setback and Geothermal Energy. In Journal of Physics: Conference Series, CISBAT 2023, Lausanne, Switzerland, 13-15 September 2023

Brown, C.S., Kolo, I., Falcone, G. and Banks, D., 2023a. Investigating scalability of deep borehole heat exchangers: Numerical modelling of arrays with varied modes of operation. *Renewable Energy*, *202*, pp.442-452.

Brown, C.S., Kolo, I., Falcone, G. and Banks, D., 2023b. Repurposing a deep geothermal exploration well for borehole thermal energy storage: Implications from statistical modelling and sensitivity analysis. *Applied Thermal Engineering*, *220*, p.119701.

Brown, C.S., Doran, H., Kolo, I., Banks, D. and Falcone, G., 2023c. Investigating the Influence of Groundwater Flow and Charge Cycle Duration on Deep Borehole Heat Exchangers for Heat Extraction and Borehole Thermal Energy Storage. *Energies*, *16*(6), p.2677.

Kolo, I., Brown, C.S., Falcone, G. and Banks, D., 2023. Repurposing a Geothermal Exploration Well as a Deep Borehole Heat Exchanger: Understanding Long-Term Effects of Lithological Layering, Flow Direction, and Circulation Flow Rate. *Sustainability*, *15*(5), p.4140.

Younger, P.L., Manning, D.A., Millward, D., Busby, J.P., Jones, C.R. and Gluyas, J.G., 2016. Geothermal exploration in the Fell Sandstone Formation (Mississippian) beneath the city centre of Newcastle upon Tyne, UK: the Newcastle Science Central deep geothermal borehole. *Quarterly Journal of Engineering Geology and Hydrogeology*, *49*(4), pp.350-363.