Title: The Low Enthalpy Geothermal Potential of Shallow Aquifers in Northern Scotland

Project rationale:

To achieve the Low Carbon Energy Transition and the challenge of meeting Net Zero it is necessary to identify and develop economically-viable, low carbon energy sources that have limited environmental impact. Geothermal energy provides such an opportunity. Despite the considerable potential of geothermal energy, to date there has been little commercial success in the UK. Historically, big capital projects have focussed on power generation in high enthalpy fractured Cornish granites; progress has been steady but slow. Feasibility studies have also addressed deep sedimentary aquifer potential across the UK, but most projects have significant geological risk and high well cost. In contrast, low enthalpy geothermal energy obtained from shallow (<200 m) groundwater sources is relatively low cost and utilises well-established technology. The Closed and Open loop Ground Source Heat Pump (GSHP) industry in the UK is growing, however it is the often the case that development of open loop resources is prevented through poor subsurface understanding.

Aims & Objectives:

The aim of this project is to establish the low enthalpy geothermal potential of northern Scotland (north of the Central Belt), an area which has received limited consideration for geothermal resource. The research has potential to encourage successful projects by de-risking the resource and could assist with providing cheap, green and reliable sources of heating or cooling, in rural "off-grid" settings, that are less connected to existing gas networks. The project has 3 main aims to: a) audit the shallow geothermal resource, b) to grade areas based on their economic heat source potential and, if possible, 3) to progress preferred options to a high-level business case.

Approach:

To audit the low enthalpy geothermal resource the student will perform an initial desktop study of the distribution of potential shallow geothermal aquifers in northern Scotland. The study will focus primarily on shallow gravel aquifers of Plio-Pleistocene and Quaternary age and, where applicable, may be supplemented by work on underlying bedrock aquifers. The student will utilise base maps and expertise provided by the British Geological Survey (BGS) as a starting point. Once identified, focus areas will be subject to more detailed study including the use of a suite of shallow geophysical techniques to constrain depth to bedrock, gravel aquifer internal properties and fluid content. The combination of shallow seismic reflection and refraction (P-wave velocity/density), passive seismic surface wave (S-wave velocity/density), resistivity tomography (conductivity) and ground penetrating radar (GPR, dielectric permittivity/velocity) will provide detailed site-specific subsurface models.

Detailed geological field mapping to determine aquifer characteristics will be undertaken. Establishing the depositional environment will be key to assessing characteristics such as porosity and permeability distribution, for example ice contact deltas, glacial outwash sheets and tunnel valleys all have significantly different heterogeneity distribution which will impact volume and aquifer flow rate. A set of screening criteria for shallow aquifer prospects will be developed which as well as geological characteristics will also include environmental (e.g. water disposal mechanisms, salinity and metal content) and economic (e.g. evidence of demand, plus possible water cooling requirements of some

industries) aspects. Following these studies, two or more sites will be selected for further feasibility work including simulation to establish economic potential.

The student will be trained in a range of applicable techniques including geological mapping, 3-D visualisation of subsurface data, groundwater flow modelling, geophysical data acquisition and processing and borehole analysis, thus providing a range transferrable skill sets that can be utilised in subsurface facing industries. The student will also be exposed to broader analysis of environmental and economic aspects. The project will benefit from quarterly meetings with TownRock Energy, a geothermal energy company who have agreed to provide advice throughout the project and Tim Kearsey (BGS groundwater specialist, Scotland).

Research Methods and Training Provision

Use of GIS techniques to map potential aquifer sites using BGS datasets. Geophysical techniques such as seismic reflection and refraction, passive seismic surface wave, resistivity tomography (conductivity) and ground penetrating radar to define aquifer area. Geological techniques: field mapping, interpretation of borehole and flow data, reservoir model builds to determine resource potential.

Training in GIS, sedimentology, field mapping and geophysical techniques will be provided by supervisors, and, where applicable supplemented by suitable training courses provided by software companies (e.g. Petrel and Eclipse in reservoir modelling). TownRock have agreed to provide mentoring regarding site selection, suitability and feasibility criteria.

Provisional Research Timetable

Year 1: Auditing the shallow geothermal groundwater resource of the study area. Establishing a GIS project with all existing mapped data, reviewing and collating published data and combining this with pre-existing mapping by BGS. Literature review of shallow groundwater aquifers and establishment of key geological, economic and environmental criteria for future screening. Publication of map of shallow geothermal potential n the study area.

Year 2: Establishing a shortlist for areas that have the potential for further study following screening. Once identified, sites will be subject to detailed field investigation, geological mapping initially. Economic and environmental considerations will also be documented. Publication of field results. Presentation at national/international conference.

Year 3: Detailed field investigations in the selected study sites. Once the sites are defined geophysical techniques can be utilised to determine subsurface characteristics. Publication of geophysical results. Presentation at international conference.

Year 4: Write up and publication of final results. Results to be presented at international conference.

Selected References

http://nora.nerc.ac.uk/id/eprint/511413/1/OR15028.pdf

http://www.largeimages.bgs.ac.uk/iip/hydromaps.html?id=scotland.jp2

Contact

For informal questions and enquiries about the project, please contact Professor Adrian Hartley at a.hartley@abdn.ac.uk