

Geothermal Market Opportunity Profile – Modelling and Simulation

Context

This opportunity profile is one in a series of profiles produced by Optimat Ltd to introduce a specific area of opportunity within the geothermal market for Scottish oil and gas companies. Optimat was commissioned in late 2021 by Scottish Enterprise to assess the geothermal market opportunities for selected oil and gas sector capability, the outputs of which included a detailed capability and market report and opportunity profiles. Geothermal energy is exploited for both power generation and heating, with many plants already established.

There are several different types of geothermal resource. In our study for Scottish Enterprise, we have focussed on the most prominent current type, namely conventional geothermal, and two emerging types that are expected to demonstrate high growth in near future, engineered geothermal systems and closed loop geothermal systems. The study also explored opportunities within mine water geothermal.

- Conventional geothermal refers to natural formation of a hydrothermal resource where water is heated in the Earth and has become trapped in porous and fractured rocks beneath a layer of relatively impermeable rock. The exploitation of conventional geothermal has focused, to date, on sites where the resource is relatively easy to access, and the resource temperature is high enough for the operation to be commercially viable.
- The term engineered or enhanced geothermal systems (EGS) refers to the practice of creating a geothermal reservoir in hot rock by injecting water into wells to create fractures. The process has generated considerable interest as EGS can be applied wherever there is hot rock at accessible depths, which is nearly everywhere on the planet.
- Closed-loop geothermal (CLG) systems use sealed wells to circulate a heat transport fluid through the subsurface. This eliminates the need for geothermal fluid flow from the reservoir formation to the surface. There is no fluid exchange with the reservoir or surrounding area – the geothermal fluid is not circulated
- Abandoned mines can be used as a geothermal energy resource, using the natural heat contained in the mine water. Heat can be extracted from the mine water by use of water-source heat pumps. As this is a low temperature resource, the heat could be used directly to either support a large heat customer (single building such as school or tower block), district heating or to feed into industrial applications, such as heating greenhouses.

It is widely recognised that Scotland’s oil and gas industry is world leading, but that it needs to adapt and diversify as we address climate change and reduce greenhouse gas emissions. Further, Scotland’s aim to achieve net zero emissions by 2045 imposes the need for the sector to change quickly. Already a number of oil and gas companies have successfully transitioned into renewable energy activities, particularly offshore wind, and it is expected that national and regional renewable energy hubs and the energy transition zone being developed in Aberdeen will further support diversification of oil and gas companies. However, it is important that additional market opportunities are identified to optimise future opportunities for oil and gas companies

The geothermal energy market is one area of opportunity which has been identified. Here, expertise developed in drilling, sub surface modelling, corrosion mitigation and data analytics could be transferred between the oil and gas and geothermal sectors.

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This opportunity profile summarises the need for modelling and simulation technologies to support the exploitation of geothermal energy.

The opportunity

Geothermal systems are complex operations that require improved modelling and simulation tools for development of deep geothermal and emerging advanced geothermal systems.

Why

Numerical models are used for financial project planning and geothermal field management, however many of the existing geothermal modelling tools were designed some time ago (over 10 years ago) and the next generation of geothermal systems require models to be considerably more detailed than previously. Modelling tools need to be able to integrate information from different disciplines and provide solutions that encompass geothermal processes (e.g. fluid flow), structures (e.g. geological faults) and conditions (e.g. supercritical temperature), enhancing the ability of developers and users to model the wide range of conditions seen in geothermal reservoirs.

Scale

The scale of the opportunity for new modelling and simulation solutions is broad and applicable across all geothermal types. The opportunity will be greater within the emerging geothermal system types, such as engineered geothermal systems (EGS), compared to more conventional operations, as these systems are more complex and the requirement to model many different variables is much greater – in EGS, hydraulic stimulation is used to create the geothermal reservoir.

In terms of geographics focus, the US is the key target market for advanced modelling and simulations solutions. The country is investing significantly in the development of EGS systems and other advanced geothermal types such as closed loop systems. Further, the US Department of Energy continues to provide funding to support research and development of innovation EGS systems and enabled technologies.

Areas of Need

The development of improved reservoir simulation has progressed from viewing reservoir fluids as idealised pure water to more realistic representation, where dissolved solids (such as NaCl) and gas fractions (such as carbon dioxide) are included. Further development is required to account for interactions between several dissolved and gaseous chemical species within the geothermal flow. A fully coupled treatment of 3D fluid flow and mass transport with detailed chemical interactions between aqueous fluids, gases, and primary mineral assemblages is very difficult.

For enhanced geothermal systems, further coupling is required, namely between fluid flow and rock stresses. Going forward, there is a clear need for simulation models for coupled thermal-hydrologic-mechanical processes.

Another emerging area of opportunity within geothermal is the use of modelling and simulation to inform predictive maintenance and asset management. To improve the average efficiency of a geothermal power plant, it needs to operate under optimum conditions to the maximum extent. Operation and maintenance of a complex system such as a geothermal power plant requires the

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collection and management of a considerable amount of information. New tools are required to provide geothermal plant operators with actionable insights from the huge amounts of data that is collected.

Route to Market

Suppliers of advanced modelling and simulation solutions and services should focus effort on engaging with the innovative start-ups that are development EGS and closed loop systems. The majority of these companies are based in the US.

Project Examples

Estimation of geothermal resource in place within a deep fault system

This research is developing new theoretical models designed to predict the geothermal resource in place and is testing these with reference to data obtained during drilling within the deep fault system in the southern St Austell Granite at the Eden Project. <https://www.edengeothermal.com/the-project/research-and-technical/geothermal-resource-in-place/>

MEET (Multidisciplinary and multi-context demonstration of EGS exploration and Exploitation Techniques and potentials)

This is an EU funded collaborative research project aiming to demonstrate the viability and sustainability of EGS in different geological settings. MEET brings together 16 European partners: small and medium enterprises, research institutes and universities, and several geothermal demonstration sites in Europe. One of the project objectives is the optimisation of the reservoir productivity and stimulation techniques. <https://cordis.europa.eu/project/id/792037>

Further Information

Examples of companies developing improved models and simulations for geothermal application would include:

- ABB offers complete turnkey instrumentation, control, electrical and optimization solutions for all geothermal power generation. Dorianno Presenti, Global Technology Solutions driver in Power and Water
- ResFrac Corp specialises in hydraulic fracturing and reservoir simulator solutions. Mark McClure, CEO