Geothermal Market Opportunity Profile – Well Engineering and Drilling

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 assesses 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.

Geothermal Market Opportunity Profile – Well Engineering and Drilling

This opportunity profile summarises the need for well engineering and drilling technologies to support the exploitation of geothermal energy.

The Opportunity

Failure of geothermal wells in an ongoing issue for the industry and advanced drilling technologies and drill tools are required to access deeper reservoirs and to support the development of emerging geothermal systems.

Why

Casing failure can have a significant impact on the productivity of the well and the ongoing maintenance costs. The problem of well structure failure is most apparent in mature conventional geothermal wells, where the wells have been designed according to oil and gas standards and not enough consideration was paid to the extreme geothermal environment. Although geothermal and oil and gas have similar well construction, high geothermal temperatures can have a significant impact on casing strength. As the well heats up, radial and axial stresses build up on the casing that is cemented in place.

New drilling technologies are under development as innovators in this field try to develop drilling solutions that will enable deeper drilling into extremely hard rock formations. EGS can benefit from a high temperature directional drilling system. Early demonstration projects have revealed that inclined wells are better for EGS than vertical wells. However, most commercial services for directional drilling systems are rated for 175°C while geothermal wells require operation at much higher temperature.

Scale

The scale of the opportunity for new casing and cementing solutions is broad and applicable across all geothermal types. The geographic focus should be on markets where there is still considerable 'low hanging fruit,' where geothermal resource is close to the surface and there is significant investment in new geothermal projects. This includes countries like Indonesia and Turkey.

Regarding directional drilling, the scale of the opportunity now, is much smaller and mainly limited to demonstration projects. However, if the predictions around future growth of EGS and closed loop are realised, shortly after 2030, there could a substantial increase in demand for directional drilling services. The geographic focus for directional drilling should be on the US, which is leading in the development of EGS and closed loop systems

Areas of Need

There is a good opportunity for oil and gas suppliers to enter this space with innovative solutions that can address the failure issues and extend the life of conventional geothermal wells. Opportunities could include new cement formulations, the inclusion of new materials in the casing to absorb the strains generated by the temperature change, and the development of flexible couplings that allows axial movement of the casing segments.

There are a broad range of drilling options under exploration and many companies are now at the stage of conducting initial field trials. There are however many technical challenges to overcome, such as how to effectively deliver the power that these techniques require from topside down many

kilometres. For EGS to make the most use of directional drilling techniques, systems need to be developed that can operate at higher temperatures, above 200°C. There is also a need for data on drill position and its status to facilitate more accurate drilling. This will require, for example, navigation and telemetry systems

Route to Market

Suppliers of well casing and cementing products and services should enter the market via established geothermal plant operators who will tender for maintenance works as required. Suppliers of directional drilling products and services should focus efforts on engaging with the innovative start-ups that are developing EGS and closed loop systems

Project Examples

Utah Forge Milford EGS Demonstrator

This is a US DOE funding EGS project located near Milford in Utah. The first of two wells has recently been completed. It was drilled vertically to about 1400m where contact was made with a granitic surface. Drilling continued to approximately 1600m, at which point the drill was directionally steered (approximately 5-degree arc per 100 feet) reaching and tangent of 65 degrees to the vertical. Drilling continued at the 65-degree angle until a total depth of 3349m (10987 feet) was reached.

The project demonstrated that this type of drilling in hard rock could be done very precisely (within about 50 feet of the planned end point). Also, a comprehensive logging programme was undertaken in an extreme environment and in situ stress measurements were acquired.

The project is planning to drill further, similar wells, and run testing programmes in the areas of:

- Reservoir characterisation (coupled imaging, drilling for interrogation and monitoring, high-temperature tools and sensors)
- Reservoir creation (formation access, fracture characterisation, zonal isolation, stimulation technologies)
- Reservoir sustainability (long-term testing, monitoring, and operational feedback)

The Utah Forge project is being delivered by a consortium of organisations, led by the Energy & Geoscience Institute, University of Utah

Further Information

Further information on the Utah Forge project can be obtained at https://utahforge.com/

Detail on funding available via the Advanced Research Projects Agency-Energy: https://arpa-e.energy.gov/

Further detail of the MM Wave drilling technology: https://www.quaise.energy/