Geothermal Market Opportunity Profile – Sensing Technologies

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 – Sensing Technologies

This opportunity profile summarises the need for sensor technologies to support the exploitation of geothermal energy.

The opportunity

The geothermal industry requires improved as well as new sensing solutions as the industry aims to increase operational efficiencies, specifically focusing on optimising drilling operations and flow assurance and to support long-term monitoring of geothermal operations.

Why

A range of sensors, for example, distributed fibre optic sensors, are used in geothermal operations for long-term monitoring of variables such as temperature. Distributed fibre optic temperature sensors can be permanently embedded within the borehole casing and used to measure temperature along the whole borehole depth. The use of continuous, real-time, down-hole monitoring can improve geothermal well efficiencies and increase well life. However, as geothermal wells move from conventional, near surface resources, to deeper operations, the industry is reaching the operational limit of current sensing options. Long-term operation of electronics at high temperatures remains a challenge for the geothermal sector; many downhole sensors are prone to failure when deployed in high-temperature wells

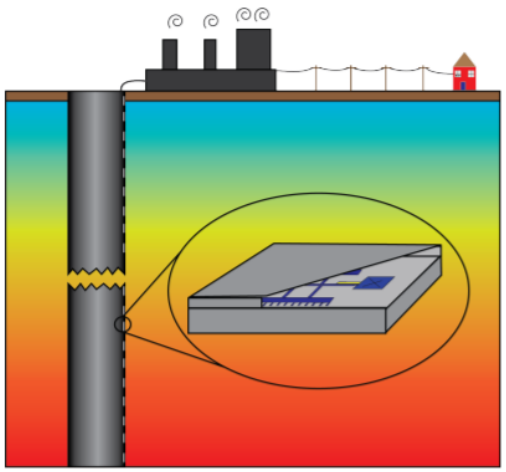
Scale

The opportunity for improved and new sensing systems is applicable across a wide range of geothermal operations. Within conventional geothermal, there is a need for robust solutions that can operate over long periods of time. EGS requires the development of high temperature and pressure sensors and instrumentation components to enable subsurface monitoring of geothermal reservoirs during stimulation and operation.

Areas of Need

Various technologies have been proposed to address the problem of long-term downhole sensing at high temperature and pressure. The following two examples demonstrate the research undertaken in this field and the opportunity for new sensing solutions:

- MEMs based sensors – microelectromechanical systems (MEMS) sensors are being explored as permanently located downhole sensing devices. MEMS-based temperature and pressure sensors using a harsh environment materials platform are currently in the design phase for down-hole monitoring.



A geothermal well is profiled with a suite of encapsulated MEMS sensors to monitor the down hole environment

- Semiconductor sensors - Silicon carbide (SiC)-based, high temperature electronics are being developed to operate at temperatures up to 300°C with appropriate robustness over long periods of use. This technology will help enable the use of more sophisticated electronics in drilling systems, sensor packages, and logging tools.

Further, high temperature electronics is seen as an enabling technology in all aspects of future geothermal developments.

In areas of micro-quakes, seismic sensors installed deep into the hot formation are required to clearly identify fault zones with higher accuracies than can be achieved with surface instrumentation.

Route to Market

The normal routes to entering this field with a sensor offering is to approach the drilling and/or well completion services companies. In the case of geothermal, it is suggested that potential suppliers approach organisations that are developing innovative solutions as these organisations will be willing to explore new options.

Project Examples

Collaboration between LYTT and Baker Hughes

This is an example of the types of collaborations being formed to explore new technology. LYTT is a provider of real-time, sensor-enabled software and analytics and Baker Hughes is a leading energy technology company. The collaboration will combine LYTT's fibre optic data analytics and cloud-based software with Baker Hughes' completions and well intervention hardware and service expertise.

Contacts:

- Tommy Langnes, co-founder and chief business development officer at LYTT
- Jim Sessions, vice president of completions and well interventions for Oilfield Services at Baker Hughes

Further Information

The development of new sensing technology and associated systems is an active field of research. Examples of organisations researching new sensors formats would include

- The National Renewable Energy Laboratory (NREL) – NREL is working with number of companies and organisations on a range of geothermal topics, from advanced geothermal systems to high-temperature electronics. Further information on NREL's activities and key contacts can be obtained at https://www.nrel.gov/geothermal/technologies.html
- Sandia National Laboratories - Sandia is a wholly owned subsidiary of Honeywell International and has been working on high temperature semiconductor technologies (Silicon-On-Insulator and Silicon-Carbide) for geothermal applications.

In terms of industry activity, in addition to the example project listed above (and contacts), we suggest new entrants engage with developers of technologies for example

- Hephae Energy Technology – Hephae is developing deep drilling technology. The company is exploring a range of technology options including the incorporation of new sensors into drill tools. John Clegg, CTO, https://www.hephaeet.com/
- Sage Geosystems – Sage is developing geothermal systems using supercritical fluids and is seeking sensors to develop better models. https://www.sagegeosystems.com