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Scotland's Geothermal Supply Chain Analysis and Global Market Opportunities Study

Final Report – Executive Summary

Scottish Enterprise

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Executive Summary

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. Geothermal energy sector development, for both power generation and heating, is one potential area of opportunity which has been identified, with previous work indicating that it offers scope for diversification for drilling, sub surface modelling, corrosion mitigation and data analytics expertise developed in the oil and gas sector.

This study, therefore, assesses the geothermal market opportunities for selected oil and gas sector capability, with a specific focus on geothermal power generation, geothermal heat production, including district heating networks, and geothermal opportunities in abandoned mines.

There are several different types of geothermal resource. In this study, 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 explores 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.

The global geothermal energy market is already established, with significant growth demonstrated over the last 10 years. This market is expected to grow significantly over the period to 2050. Global geothermal electricity generation, including engineered geothermal systems, is expected to grow by a factor of ten over the period from 2020 to 2050. In terms of the European market, it is estimated that Europe has an installed geothermal electricity capacity of 3.5 GWe in 2020, distributed over 139 power plants.

A wide range of geothermal temperatures can be used for heating, in applications such as space and district heating, spa and swimming pool heating, greenhouse and aquaculture ponds heating and for industrial processes. The global geothermal direct use market is predicted to grow by a factor of six over

the period from 2020 to 2050. There were 350 geothermal district heating systems in operation in Europe in 2020 and a further 232 were in various stages of development

The largest geographic electricity generation markets are the USA, Indonesia, the Philippines and Turkey, with all these countries also having large portfolios of planned projects. The USA had an installed geothermal energy capacity of 3,676 MW in 2019, with 2,133 MW installed in Indonesia, 1,918 MW in the Philippines and 1,526 MW in Turkey, with Indonesia is set to become the leading geothermal market.

Almost 220 oil and gas supply chain companies that have capabilities that offer the potential for diversification into the geothermal supply chain were identified. These can be segmented as follows:

- Well engineering 131 companies
- Sub-surface modelling 15 companies
- Corrosion mitigation 25 companies
- Data 46 companies

Further, a significant number of these companies have demonstrated the potential to innovate and / or to access international markets

The geothermal sector has a number of technical challenges to address as it continues to grow and maximise output. These are listed in the following figure:

Conventional Geothermal	Deep Geothermal	Engineered Geothermal Systems	Closed Loops Geothermal Systems	Abandoned Mines
Well structure failure	New drilling techniques	Directional Drilling	Complex and accurate directional drilling	Modelling to understand heat depletion
Corrosion and scaling	New tools	Real-time data and long-term monitoring		
High flow rates	Improved modelling and simulation		Use of advanced fluids	Corrosion and fouling
Failure of pumps		Transfer of knowledge from shale gas fracking	Advanced turbines	
Integrated design	Minimise maintenance			
	Improved sensors			

Geographic geothermal markets are dependent on the specific geological conditions in different regions. As a result, similar geological conditions are being exploited in similar ways in different regions, leading to similar challenges and, thus, opportunities in these regions.

These challenges offer opportunities for new entrants to the sector. Sixteen specific areas of opportunity for Scottish oil and gas companies were identified through analysis of these technical challenges. The opportunities that are considered to be most attractive are:

- Improved well structure (casing, tubulars, cementing etc.)
- Corrosion and scaling prevention and maintenance
- Sensing technology to support measurement while drilling (high temp and pressure)
- Sensing technology to support long term monitoring
- Sensing technology to support flow assurance
- Improved subsurface and surface physical modelling to support reservoir characterisation and prediction of production

Based on the work carried out in this study it is recommended that:

- Scottish oil and gas companies are encouraged to pursue geothermal market opportunities

- Priority markets for Scotland, based on current activities, future growth and need for new technologies are Turkey, Indonesia, the USA and Germany. These should be initial target markets for development.
- More in-depth analysis of specific opportunities is carried out to support Scottish companies pursue them
- Access to a database of developing and new geothermal projects and contracts is established to identify forthcoming opportunities for Scottish companies
- Market access mechanisms, through a range of linkages, including diversified oil and gas companies and national renewable energy organisations, are developed

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