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The OptiDrill project is optimising geothermal drilling operations with Machine Learning

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The OptiDrill project is working on developing a real-time advisory system to overcome the socio-

techno-economic uncertainties of deep geothermal drilling.



Geothermal has been considered one of the most carbon-neutral, sustainable, and renewable sources of energy that can provide both baseload and dispatchable power to the grid.

Despite its potential to be an important player in the transition to a net-zero future, geothermal is presently the most underutilised renewable resource due to the high cost of deep geothermal.

A major element of the cost in any geothermal project relates to drilling and completion, accounting for up to 70% of the overall project development. In addition to that, the drilling industry faces several challenges when it comes to geothermal well drilling and completions, such as low rate of penetration (ROP) and lack of bottom hole awareness, resulting in tripping and non-productive time (NPT) spent on formation characteristics.

The industry lacks digitisation and automation, relying on personal skills and old data. Existing drilling systems are designed for hydrocarbon basins with oil-based muds, limiting their usefulness for geothermal and hard rock formations.

Current systems are also based on rotary drilling, whereas the geothermal drilling sector requires new technologies like percussion and non-contact thermal drilling.



The digital transformation of the upstream energy industry has spawned exponential growth in the amounts and types of data generated in recent years. Advancements in Machine Learning (ML) and Artificial Intelligence (AI) are creating opportunities for innovation and optimisation in the geothermal drilling industry. These innovative tools improve the accuracy and the cost of geothermal exploration and optimise geothermal operations – driving down the overall cost of geothermal energy.

The use of Machine Learning algorithms can help to identify anomalous responses in data and to differentiate between drilling problems and operational or logistical difficulties. By developing remediation strategies based on the findings, it may be possible to de-risk deep geothermal heat projects and make them more attractive to investors.

The OptiDrill project

The OptiDrill project is funded by the European Commission's Horizon 2020 grant that aims to develop Machine Learning modules under a unified advisory system. Each module will be responsible for either analysis, prediction, or optimisation of one aspect of the drilling or completion process.

The OptiDrill system design revolves around developing a system that can improve drilling efficiency in any formation. The focus is set to take advantage of the existing data and knowledge transfer, solve the existing problems, and enhance

the existing methods and technologies by employing the following approaches under an integrated framework of the OptiDrill geothermal drilling advisory system:

- Digitalisation of previous drilling data and text-based reports through Natural Language Processing (NLP) deep learning methods to create a digital database of drilling and completion daily reports and problems pave the way to the digitalisation of daily drilling reporting and enable the further transfer of knowledge from the oil and gas sector;
- Instrumentation of the drilling process through the implementation of the drill rig and bottom assembly (BHA) compatible sensor strings and data transfer system alongside respective methodologies to measure drill-induced parameters (such as vibrations, load, torque, flow and acoustic signals), and to interpret their effects on the process;
- Reservoir simulated and field-scale experimental data to fill the gaps in the available datasets and simulate various drilling problem scenarios, including 'what-if' scenarios. A complete, gapless database will enable the models to reach their highest prediction proficiencies even in formation or situation scenarios for which there has been very little previous recorded data available;
- Geothermal drilling modelling and performance prediction and optimisation by the employment of a combination of Machine Learning and novel deep learning methods;
- Real-time lithology prediction of the formation by employing coupled deep learning methods in combination with



novel sensor strings data for model validation and efficiency enhancement;

- Prediction and trigger detection of drilling problems through data-driven statistical and Machine Learning methods to avoid unnecessary and costly risks and reduce NPT during drilling and completion processes;
- Well completion and enhancement modelling for horizontal – multilateral wells clusters, and performance prediction and optimisation by the employment of a combination of Machine Learning and novel deep learning methods;
- Statistical modelling validation and optimisation of the Machine Learning models; and
- Federate ML scheme in combination with self-learning ML algorithms will give the OptiDrill system a unique possibility to be updated through every new drilling and completion activity. The feature will ensure a future-proof, self-evolving capability of the OptiDrill advisory system.

The OptiDrill is an industry-led project, and the consortium is composed of 11 partners from highly experienced drillers and operators, drilling consultants, research organisations and technology experts, including:





- Fraunhofer IEG, previously known as International Geothermal Centre (GZB), is one of the most advanced institutes for geothermal drilling with years of experience in the application of ML and to geothermal drilling and the only institute that has facilities to simulate reservoir and deep drilling conditions in Europe;
- Another research organisation is the British Geological Survey (BGS), which has world-leading data on geological surveys and will validate the model using statistical methods;
- ON power, Geothermal Engineering Ltd (GEL), Bestec GMBH, Radial Drilling Europe BV, ENBW Energie Baden-Württemberg AG, and Well Guidance B.V., the largest operators of geothermal power, will be sharing data from wells drilling, jetting, well completion, etc.;
- Precision Varionic International Limited (PVI) is a sensor system expert;
- Geolorn Limited (GEO) will be leading the commercialisation of the technology and industrial applications; and
- Technovative Solutions Ltd (TVS) is a monitoring and control system, database and Machine Learning expert.

OptiDrill consortium partners have access to drilling and logging data from over 500 wells and hundreds of formations varying from soft mudstones to very hard igneous and metamorphic rocks. Also, we will be getting data from two deep geothermal wells in the UK – Eden Project (4.5km) and United Downs Project (5.2km). In addition to drilling partners,

we will also have data from the Parta project in Romania, ÉS-Géothermie (for data from Paris basin, France), Koekoekspolder (Netherlands), Federal Institute for Geoscience and Natural Resources (Germany) and VITO (Belgium). We are also in discussion with Dago, Hogewerf, ACL etc, for drilling and logging data.

The OptiDrill system will be validated in relevant operational conditions at a partner's drill rig at technology readiness level (TRL) 5.

The impact of the project

The Machine Learning models of ROP, lithology, drilling problems, well completion and enhancement, and coupled geothermal drilling optimisation models developed by the OptiDrill project, are designed to improve ROP, lifetime and reliability compared to existing technologies. OptiDrill coupled drilling optimisation ML models in the drilling advisory system will enable drillers to reach cost-effectively greater depths and higher temperatures on all types of geological formations for geothermal drilling. This project is designed to optimise the drilling parameters, thereby speeding up production and injection wells drilling for geothermal power. It will enhance the growth of geothermal energy by significantly reducing geothermal power plant capital expenditure (CapEx) spent on drilling while also significantly reducing the environmental impact during installation.





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*Please note, this article will also appear in the fourteenth edition of our **quarterly publication**.*

