Deep drilling costs reduction

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ABSTRACT

Drilling represents from 30% to 50% of the cost of a hydrothermal geothermal electricity and heat projects and more than half of the total cost of Enhanced Geothermal Systems (EGS). This paper aims at presenting non-technical proposals to overcome this substantial financial barrier. Deep drilling costs can be reduced:

- With RD&D activities
- With Learning by doing series of drilling
- With a better functioning drilling market

Research and Development (R&D) can improve geothermal drilling technologies in order to reduce its costs. R&D should focus both on novel drilling concepts and on improvements to current drilling technology, as well as for other ways to optimize the economics of drilling operations (horizontal, multi-wells etc.). Nowadays, drilling for deep geothermal energy is done using equipment originally intended for the hydrocarbon industry. The target is to reduce cost for drilling and underground installations in 2020/2025 by at least 25 % compared to the situation today.

By developing more deep geothermal projects in a region, and multi-wells project, the well fields will see a cost reduction of the drilling.

Another challenge today is to improve market conditions for geothermal deep drilling. The deep geothermal drilling market could be more integrated with more access to available geothermal drilling cost data. Moreover, the interaction between project developers and drilling contractors could be improved.

Following the previous work done during GEOELEC project, the paper will draw some new proposals to overcome this issue of Deep drilling costs and market.

1. INTRODUCTION

Drilling represents from 30% to 50% of the cost of hydrothermal geothermal electricity and heat projects and more than half of the total cost of Enhanced/Engineered Geothermal Systems (EGS). Moreover, success rate in drilling for geothermal projects is about 50% in green fields and 75% in operated fields.

The significant costs and low success rate are the main reasons for the European Geothermal Energy Council to present this in-depth analysis of the drilling market in Europe today, having focused its analysis on turbines over the last two years.

Although geothermal drilling often uses the same technology as the oil and gas industry, particularly in low enthalpy sedimentary settings, geothermal drilling displays several distinctive attributes. The established deep drilling technique is rotary drilling; the tri-cone rotary bit, used since 1909, was supplemented in the 1970's by the polycrystalline diamond bit. A wide variety of rotary techniques exist, amongst which hydraulic, electrically driven drilling is best suited to deep seated targets. Geothermal drilling benefits from on-going industry improvements both in terms of drilling tools and concepts. Despite these improvements, drilling costs continue to be high and therefore considerable emphasis needs to be placed on the development of new drilling technologies.

Research and Development (R&D) can improve geothermal drilling technologies in order to reduce costs, but the main challenge today is to improve market conditions for geothermal deep drilling, a market which has still not been thoroughly assessed. Problems include limited access to available geothermal drilling cost data and limited interaction between project developers and drilling contractors.

2. TECHNOLOGY

Five generations of deep drilling techniques (figure 1) for geothermal have been seen since the first development of geothermal power in 1913 and of district heating mainly after the 1960s. The trend has always been to allow cost reduction and to improve efficiency and reliability.

The first generation saw two vertical wells drilled from a two distant drill pads, while the second introduced deviated wells and single drill pads. The next generations were focused mainly on improving the design of deviated wells until deviated symmetric wells were developed. The fifth generation proposed for the first time (sub) horizontal wells for deep

geothermal. This is, for example, the technology currently used in the Paris basin for new geothermal DH systems.

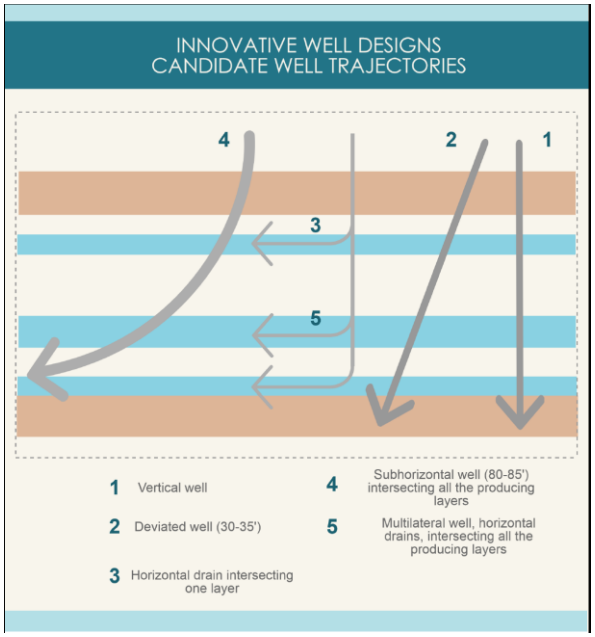


Figure 1: Drilling - Innovative wells

On top of improving the drilling concepts, the trend has always been to reduce drilling costs by decreasing drilling duration. Better drilling equipment and better knowledge of the underground environment can save both time and money.

Technological development (see figure 2) should focus both on novel drilling concepts and on improvements to current drilling technology, as well as other ways to optimise the economics of drilling operations (horizontal, multi-wells etc.). The target is to reduce costs for drilling and underground installations in 2020/2025 by at least 25% compared to the situation today. Nowadays, drilling for deep geothermal energy uses equipment originally intended for the hydrocarbon industry.

New drilling technologies developed in the oil and gas sector could be replicated for geothermal: multi-well pad, new vertical drilling systems etc. Some potential breakthrough technologies have been demonstrated in the laboratory and now need to be tested under field conditions at significant depths. These include: jetting (high performance/mud jet bits), thermal drilling (spallation, plasma bit), direct stream, millimetre wave, and high voltage electro impulses.

Currently, two research projects focusing on deep drilling, both of which began in 2015, are operating within the European Union R&D programme Horizon 2020. The DESCRAMBLE project focuses on drilling into super-critical conditions and studying drilling components, in addition to well completion materials, design, and control. The THERMODRILL project objectives are to focus on conventional rotary drilling with water jetting to achieve 50% faster drilling in hard rock in addition to reducing costs by 30%, whilst also reducing induced seismicity risks.

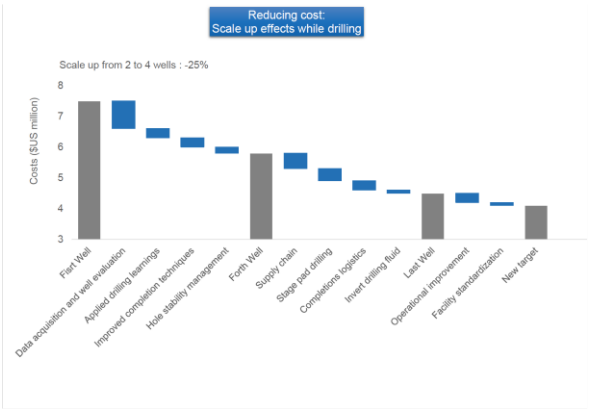


Figure 2: Drilling - Reducing drilling cost

On top of technological developments, drilling costs are dependent on the rig demand (mainly for oil & gas, therefore dependant on crude oil prices), the drilling price (€/m), and the raw material cost. It is therefore key to improve market conditions concerning drilling rigs, to save time (for example with the use of multi-well pads, etc.), and for tools such as drill bits to be reliable and not require frequent changes. The challenge of deep drilling for geothermal is to move from an exponential well cost curve to a linear curve when drilling deeper.

On top of the R&D activities described above, it is notable that drilling costs reduce when more projects are developed in a given region, and when multi-well projects are developed. Such a cost reduction has been demonstrated by the project in Unterföring (Germany) developed by Erdwerk gmbh. In 2009, the first two wells in Unterföhring had drilling costs of 1400€/m then, two years after, a project in nearby Ismaning had a drilling costs of 1150 €/m; by 2014 when two new wells were drilled for the expansion of the Unterföring system, the drilling cost was 1100€/m. In five years, drilling costs were been reduced by more than 25%, principally through ‘learning by doing’.

2. DRILLING MARKET

During 2015, the Baker Hugues international rig count (Baker Hughes has issued the rotary rig counts as a service to the industry since 1944, when Hughes Tool Company began weekly counts of U.S. and Canadian drilling activity. Hughes initiated the monthly international rig count in 1975: http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsintl) showed that of the 2337 rigs used worldwide (on average), 117 were used in Europe. Three quarters of the rigs in Europe were operating on land, and more than 70% drilled for oil and gas operations. It should be underlined that around 4000 rigs are available for drilling worldwide.

Between one and three rigs have been used in France, Germany, Hungary, Iceland, Italy and Netherlands, and more than thirty rigs have been used for geothermal in Turkey. Still today, the geothermal industry uses the same rigs as the oil and gas industry.

This is a key factor which influences the drilling market for geothermal. Geothermal drilling costs tend to follow the general oil and gas industry trend as depicted in figure 3 which exemplifies a total dependence on crude oil prices. This situation is likely to persist as long as the geothermal drilling sector does not build up a strong market share of its own.

The GEOELEC database of deep drilling companies active in the geothermal sector in Europe lists the main deep drilling contractors operating in Europe and further afield. Around 20 equipment manufacturer/provider and drilling service company and 20 drillers/rig owners are operating in Europe

Drilling market conditions are different all over Europe. Firstly, drilling regulations have a national component which creates a barrier to the creation of a European market.



Figure 3: Drilling - Geothermal drilling index

In some countries, the number of drilling companies is not high enough to allow full competition and therefore competitive prices. For example, the typical components of drilling contracts in the geothermal drilling market in Europe are:

• France: rig daily rate, lump sum

• Germany: metre rate, rig daily rate and lump sum

• Italy: rig daily rate

• The Netherlands: lump sum, rig daily rate

• Iceland: Integrated meter rates contracts

Day rate contracts are the most common, when turnkey contracts are used in smaller projects and water well drilling. We can see also integrated contracts with a mix of meter rate, day rate and turnkey contracts. The advantages of such contracts are that if everything is normal and the well is drilled as designed, the prize is then more or less fixed. The contractor is paid for each meter drilled. The contractor and the developer split the risk of damages in the hole up to a limit. So, the responsibility is greater on the contractor and the trust has to be between the parties. Unexpected delays related to hard rock, bad performance or weather condition is on the contractor. Hourly rate is paid for downhole problems due to difficult geological conditions by developer. The contractor is supplying all drilling services (casing running, cementing, directional drilling, logging etc.). The contractor is supplying all equipment's for drilling: drill bits, stab, DC, DP, mud motors, jars etc. The contractor is supplying all drilling consumables: drilling mud, cement, casing and casing accessories… These integrated contracts are recommended for small developers, new developers coming into the marked and operation in remote locations.

For the recently attributed drilling contract about the Þeistareykir Geothermal Power Project in Iceland, Landsvirkjun adopted a combined Integrated and hybrid-type drilling contract for ten wells. In top, we can notice some more specificity for this drilling contract. The call was an open tender published on EEA, in English, following the FIDIC terms. Non awarded bids 2, 3 and 4 received a financial compensation of $50.000 paid. The hybrid-type drilling contract had the following conditions:

▪ Meterage payments for drilling, casing run and casing cementing

▪ Day-rate payments for logging, stuck-in hole more than

▪Lump-sum payments for rig mobilization, installation of wellhead etc…

▪ Risk sharing for loss-in-hole, well direction etc…

Another important parameter influencing the market is rig availability. Although the total number of rigs in Europe is enough for the geothermal operations currently developed, it can be the case that the rig required for a drilling is not available when needed by the project developers. The contractual relationship between geothermal developers and drilling companies is a key factor of the project and cost management. An innovative market approach has been recently developed in France. A specific drilling management contract has been developed by the French operator Fonroche Geothermie through a joint venture with Herrenknecht Vertical and Anger's & Soene, in order to build and operate an innovative a heavy land rig adapted to urban environmental constraints and deep targets (down to 6000m True Vertical Depth: TVD). This long term commitment brings price stability and availability for the ongoing development of deep geothermal exploration in France.

3. FOCUS ON TURKEY

As presented in the market analysis above, Turkey is today the hot market for geothermal project development and for geothermal drilling. This analysis of the drilling market and drilling conditions in Turkey further details the statements above.

In Turkey, 82 geothermal wells were drilled in 2013, and around 104 in 2014. More than 30 rigs are active in the Turkish geothermal drilling market, 90% of which are active in Menderes and the Alasehir Graben. Drilling equipment in Turkey is rather old fashioned but developers benefit from Government funding for early exploration (MTA). Moreover, the Government is undertaking discovery and confirmation drilling. The regulatory framework in Turkey for geothermal drilling operations is improving with the development of the sector but developers still find that time is wasted due to administrative procedures stemming from the oil and gas framework.

Drilling in Turkey benefits from the same conditions as other medium enthalpy areas in the world, meaning costs for casing, well heads, and costs of cementing services are lower than in High enthalpy areas. There are low management costs and low service costs for mud and cementing.

Rig rates are rather low at $ 15-19 K/day, in comparison with the global rig rate of $ 25-27 K/day.

• A 1500/2000 m well, drilled in 30/40 days, would cost ca 1,858,000 USD

• A 2000/2500 m well, drilled in 40/50 days, would cost around 2,900,000 USD

• A 2800/3500 well, drilled in 60/70 days, would have a cost of approximatively 3,650,00 USD.

The penetration rate of geothermal drilling in Turkey is rather high, similar to Kenya and Iceland for example, average drilling has a penetration of around 500 Managed Pressure Drilling (mpd)[1]. This means that the total development period of a project in a proven field in Turkey can be reduced to duration of 36 months.

4. DRILLING COST

Acknowledging that drilling is the most costly phase of a deep geothermal project, between 40% and 75% in Europe, it is key to analyse the composition of the drilling costs, the influencing factors and the potential reduction of drilling costs.

A drilling cost includes the following elements:

▪ Drilling rig with all equipment incl. BOP

▪ Drilling tools incl. bits, fishing tools etc.

▪ Materials incl. cement, mud etc.

▪ Drillers : drilling crew, drilling supervisor etc.

They operate the following works:

▪ Rig mobilisation

▪ Drilling incl. directional drilling services

▪ Mud engineering

▪ Casing run

▪ Casing cementing

Presenting the factors influencing the drilling costs is rather a complex task as they are numerous being technical, technological, regulatory, financial and economical.

On a technical point of view, using old or recent rigs, bits and other materials or having experienced drillers or young ones can change the costs. It is one reason for explaining the difference between Turkey and Germany for example. We can highlight the importance of having properly trained and experienced drillers.

On a technological aspect, it is clear that it is not the geothermal sector which influences the technological development and the costs but the oil and gas sector. But using the proper rigs and bits, traditionally operated for oil and gas, will influence substantially the drilling cost of a project.

One key factor, not enough considered, is about the regulatory conditions. We can there consider two dimensions: the nature of the regulations and its local or national aspect. The regulatory framework for drilling cover environmental rules, rules of mining authorities regarding protection and workers safety and mining permits. Standards and norms (ISO and API) are also regulating this sector. Competition rules are also important (see paragraph below on economics). Stricter regulations influence negatively the costs, but minimum rules are necessary for mitigating the environmental impact. Here it is important that the specificities and criteria of national rules are a barrier to the creation of a European drilling market and allow competition.

The financing of the drilling is not specific in it but is including in the project financing. Of course, it is the key phase as it is the most capital intensive one and due to its risk component. The financing has not the same cost being public or private, in a juvenile or a mature market. The interest rates propose for the drilling operation influence the costs as we underlined above, this phase of the project is capital intensive with a total costs ranging from 6 to 20 Mio €.

Finally, the drilling costs are influencing by the economic and market conditions. It relates here with the degree of competition between the drillers, the oil price and the project management. Many countries do not have national drilling companies, in others only

[1] Definition of MPD adopted by the IADC: “Managed Pressure Drilling (MPD) is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.

few are operating. The contractual relationship between project developers the drillers, described above, is also influencing the drilling cost. The oil price influences the drilling costs for geothermal, as described with the graph on the drilling index. Drillers are proposing more rigs to geothermal when oil price is low. Finally, drilling costs can be reduced by saving time. This relates with drilling management onsite, work organisation and materials supply. Training, education and experience help to improve the drilling management.

The potential reduction of drilling costs should operate by working on these five factors.

The technical and technological development could lead to drilling costs reduction, but they will be largely influenced by the oil and gas sector. If improving current drilling technologies and concept will have an, impact at medium term, novel drilling technologies will only be available at the long term. At short term, one should work on technological development with learning-by-doing/drilling with a drilling operation covering several wells on a single project. Having more professionalised drillers would help in some countries to decrease costs.

We can consider together the regulatory, economic and financial conditions. The creation of a European geothermal drilling market and the adaptation of conditions according to the maturity of the market will help to mitigate drilling costs.

5. CONCLUSIONS

In the near future, the main driver for the reduction of costs of power and heat production leading towards grid parity will be the drilling cost. The drilling costs are expected to decrease firstly with learning-by-doing. The cost reduction will essentially be through better use of the current drilling rigs, a decrease in the number of hours to drill a well, and an increase in the number of wells per site (from two -four towards four-eight wells per site). This highlights the importance of engineering for the cost of drilling operations.

Current experiences in geothermal confirms that new technology and concepts in drilling help to save money. Because of the low market price of oil in 2016, drilling and service costs are lower than two years ago. Geothermal developers are starting to focus on saving time to further decrease costs. For example, performance and deviated wells drilling in geothermal are increasing in Turkey; and (sub) horizontal wells for deep geothermal will be developed in France in 2017. In Turkey, the expectation is to reduce the number of drilling hours for a well from ca. 300h to less than 130h, a reduction by a factor of more than two.

Further research and development to improve current technologies is expected to decrease costs by more than 20% in the next ten years. Long-term cost reduction will be brought about by novel drilling technologies becoming mature.

The market conditions for geothermal drilling are, however, not expected to change dramatically until the development of a substantial number of deep geothermal projects and the creation of a proper geothermal drilling industry. In the geothermal drilling market, price elasticity will remain low.

The crude oil price and the demand or supply of rigs or wells drilled in the near future is hard to forecast precisely, and the impact on the drilling costs for geothermal are rather uncertain.

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Acknowledgements

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