Leveraging Experience From the Upstream Oil and Gas Industry in Unconventional Geothermal Wells

Hephae Energy Technology

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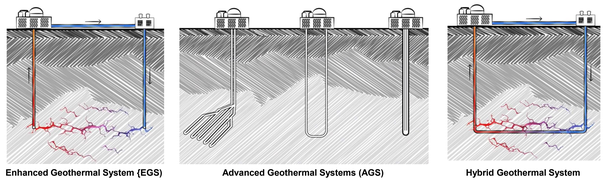
Unconventional Geothermal

Unconventional wells could revolutionize the geothermal industry. Effectively creating their own reservoir, they will allow geothermal wells to be drilled anywhere there is heat beneath the ground – in practice, this means literally anywhere on the planet!



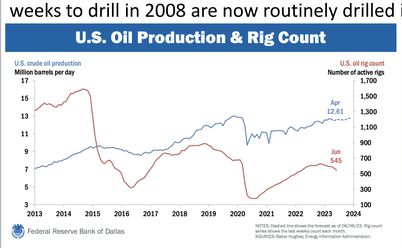
(images courtesy J. Beard/Pivot2021: Geothermal Reimagined)

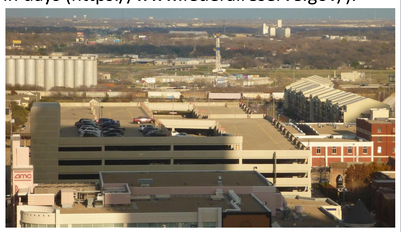
As with most new technologies, unconventional geothermal wells currently appear in many proposed forms. In time, many of these will fall by the wayside and one or two techniques will come to dominate. At present, it's impossible to predict which will dominate, but all of them will require some form of directional drilling.

Our vision is for our industry to drill one million geothermal wells by 2050. This is achievable based on the number of oil and gas wells drilled per year and will allow geothermal to contribute approximately 16% of the world's energy requirements by then. Our mission is to provide the high temperature technology needed to enable the drilling of hotter, deeper wells and thereby create the potential for greater recovery and power generation.

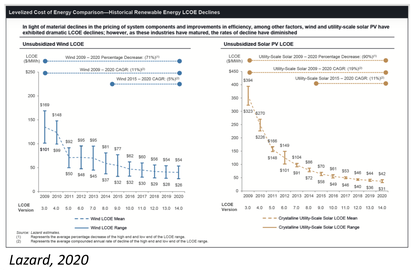
Productivity Gains in the Oil and Gas Industry

The rise of unconventional oil and gas drilling beginning in 2008 caused dramatic and sustained improvements in the efficiency of drilling wells. Well profiles that may have taken weeks to drill in 2008 are now routinely drilled in days (https://www.federalreserve.gov/).





Unconventional geothermal wells can benefit in a similar way from so-called "factory drilling" whereby all wells are drilled in the same way, resulting in significant savings when compared with existing drilling costs. This will directly contribute to an exponential reduction in costs similar to that seen in wind and solar over the last decade.

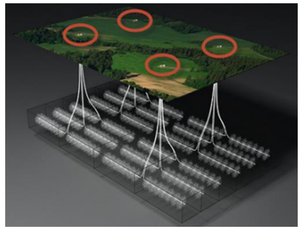


Lazard, 2020

Starting in the 1920s, the oil and gas industry took 100 years to learn how to quickly, effectively and repeatably drill complex directional wells. The unconventional geothermal industry has an opportunity to leverage that learning and accelerate its own development. The only missing piece is the ability to work at the higher temperatures that geothermal wells will demand in order to optimise production of power.

Horizontal Wells

The image below shows a typical unconventional spread in the oil and gas industry, with multiple horizontal wells drilled from the same surface location. Regardless of which unconventional geothermal technology prevails, we believe that geothermal installations could look very similar to this:



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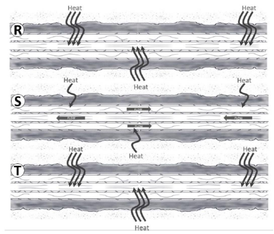


Figure 6: Active process of Thermal Soak Method

Bohlander, Bohlander & Swanson

- Because it will make sense to drill along isotherms (lines of constant temperature) in order to maximize exposure to the highest possible formation temperatures while staying within the bounds of equipment capabilities and temperature limits
- Because EGS wells will require multiple parallel wells in order to optimize communication between fractures
- Because AGS wells will require recovery time (see Bohlander, Bohlander and Swanson, 2021, GRC Transactions Vol 45) which suggests multilaterals will be needed.

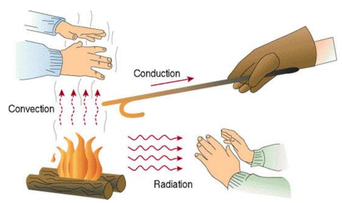
We have spoken to nine key leaders in unconventional (EGS or AGS) technology, and all of them state either explicitly (on their website or in technical papers) or implicitly (in conversations at conferences) that horizontal wells will be part of the solution. Fervo's test well results announced in July 2023 (fervo.com) support this and show a pathway to even higher power generation at higher temperatures than the 191°C they achieved.

Developing High Temperature Electronics

The value of higher temperature wells suggests that the key to transferring unconventional oil and gas drilling technology (and other technologies) to geothermal is temperature resistance. This has been achieved up to 200°C in oil and gas by completely re-thinking the packaging and materials used for the electronics and sensors. See the SPE paper referred to as an example.

Kleawyothatis el at, 2018, SPE-191054-MS

The electronics we plan to develop will initially operate at up to 210°C, extending eventually to at least 300°C and possibly beyond. This will require another radical re-think of how electronics is designed. All we can say for now is that our electronics will look nothing like the image above, or for that matter nothing like more conventional Measurement While Drilling (MWD) electronics used in the oil and gas industry. We will have to make use of all methods to get heat away from our sensitive components: conduction; convection; advection – while at the same time managing radiation of heat from the hot formation around the tool.



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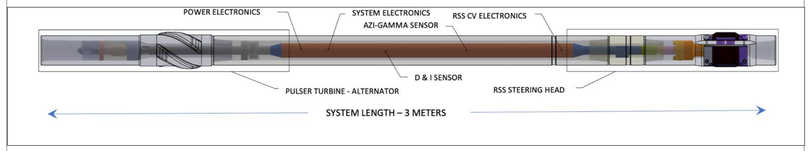
Integrated High Temperature Directional Drilling Tool

To enable the drilling of deep, accurate wells in basement formations, which themselves are likely to have higher friction than sedimentary rocks, will require accurate measurement and steering technologies. Therefore, in addition to MWD, a high temperature version of the Rotary Steerable System (RSS) tools used in oil and gas wells will be needed.

Here, it is possible to build a tool that will be simpler, and inherently lower cost, than its oil and gas cousins. For largely historic reasons, MWD and RSS tools in oil and gas developed independently of one another and are usually discrete tools, albeit often connected on the same bus or by some sort of short-distance communications link. This means a lot of duplication: of sensors; processors; memory; power supplies and so on.

Because we are building a tool from scratch, we can combine these functions and eliminate duplication – something oil and gas would do if only it could. This will save cost but equally (if not more) importantly it will increase reliability. All the reliability risk at the high temperatures we are targeting is in the sensors and the electronics, and the fewer there are, the smaller the risk.



Building Blocks

Development of a high temperature drilling system will require careful selection, screening, testing and developing of a wide variety of sensors and components. It will require the exploration of new materials and construction techniques for PCBs, as well as techniques for mounting and cooling of these boards – or at the very least, techniques for managing heat transfer away from them.

These techniques will be directly applicable to other applications which will also be usiefil to geothermal wells, and these will all be directly enabled by the learnings from development of the high temperature system. These include:

- Other drilling-related measurements
- Logging
- Intelligent completions
- Production monitoring
- Production optimization

Conclusion

New technology transformed and scaled unconventional oil and gas and allowed significant reduction in drilling costs and associated improvements in extraction economics.

As one example, there is a century of directional drilling experience gained in the oil and gas industry. If we can combine this expertise with new high temperature components and systems design, plus decades of geothermal experience, we will have all the pieces of the puzzle needed to scale geothermal to previously unimagined heights.

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