Geothermal Energy Overcomes Major Obstacle

By John Benson

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1. Introduction

The good news is that geothermal energy, as I've written in a 2021 post below, may be the perfect renewable.

This post will start in my deep past, over 40 years ago and travel several decades into the future. The subject of this post is Geothermal Power, a renewable energy source that was first used to generate electricity in Larderello, Italy, in 1904, and thus is one of the oldest renewable energy sources. It has been used in my home state (California) to generate a significant amount of our electric energy since the early 1960s.

In 1985 I became heavily involved with the Geysers Geothermal Generating Field, what is now (still) is the largest in the world by several metrics.

However, I have never posted a paper about Geothermal Power. I have decided to rectify this failure and write this post. As I started researching this, I found that this technology has not only been amazing in the past and present, it will be important to our efforts to overcome climate change in the future.

https://energycentral.com/c/cp/hot-rocks-%E2%80%93-perfect-renewable-energy

The other good news is that geothermal power has a strong technology base in the petroleum industry. Drilling holes in the ground to extract geothermal steam uses the same tech as drilling holes to extract oil & natural gas. The bad news is that it's damned expensive, and depending on the specifics of a given (petroleum or geothermal) project may not be justified based on the return on investment. Also, geothermal production requires two wells – one to extract the steam and another to reinject the condensate.

2. Current State of Geothermal

The upper 10 kilometers of the Earth's crust contains vast geothermal reserves, essentially awaiting human energy consumption to begin to tap into its unstinting power output—which itself yields no greenhouse gasses. And yet, geothermal sources currently produce only three-tenths of one percent of the world's electricity. This promising energy source has long been limited by the extraordinary challenges of drilling holes that are deep enough to access the intense heat below the Earth's surface.[1]

Now, an MIT spin-off says it has found a solution in an innovative technology that could dramatically reduce the costs and timelines of drilling to fantastic depths. Quaise Energy, based in Cambridge, Mass., plans to deploy what are called gyrotron drills to vaporize rock using powerful microwaves.

Author's comment: Normal petroleum drilling technology uses rotating drill bits (see the image on the top of the next page) composed of effectively a large number of pointed chisels tipped with industrial diamonds. Not only are they extremely expensive, they don't last very long.

[1] Tom Clynes, IEEE Spectrum, "Fusion Tech Finds Geothermal Energy Application," March 29, 2024, https://spectrum.ieee.org/geothermal-energy-gyrotron-quaise

A gyrotron uses high-power, linear-beam vacuum tubes to generate millimeter-length electromagnetic waves. Invented by Soviet scientists in the 1960s, gyrotrons are used in nuclear fusion research experiments to heat and control plasma. Quaise has raised $95 million from investors, including Japan's Mitsubishi, to develop technology that would enable it to quickly and efficiently drill up to 20 km deep, closer to the Earth's core than ever before.

"Supercritical geothermal power has the potential to replace fossil fuels and finally give us a pathway to an energy transition to carbon-free, baseload energy," says Quaise CEO Carlos Araque, a veteran of the oil and gas industry and former technical director of The Engine Accelerator, MIT's platform to commercialize world-changing technologies. "We need to go deeper and hotter to make geothermal energy viable outside of places like Iceland."

The deepest man-made hole, which extends 12,262 meters below the surface of Siberia, took nearly 20 years to drill. As the shaft went deeper, progress declined to less than a meter per hour—a rate that finally decreased to zero as the work was abandoned in 1992. That attempt and similar projects have made it clear that conventional drills are no match for the high temperatures and pressures deep in the Earth's crust.

"But an energy beam doesn't have those kinds of limits," says Paul Woskov, senior research engineer at MIT's Plasma Science and Fusion Center. Woskov spent decades working with powerful microwave beams, steering them into precise locations to heat hydrogen fuel above 100 million degrees to initiate fusion reactions.

“I was already aware that these sources were quite damaging to materials because one of the challenges is not to melt the inner chamber of a tokamak,” a device that confines a plasma using magnetic fields. “So it wasn’t much of a jump to make the connection that if we can melt steel chambers and vaporize them, we could melt rocks.”

In 2008, Woskov began intensively studying whether the approach could be an affordable improvement on mechanical drilling. The research led to hands-on experiments in which Woskov used a small gyrotron to blast through bricks of basalt.

Based on his experiments and other research, Woskov calculated that a millimeter-wave source targeted through a roughly 20 centimeter waveguide could blast a basketball-size hole into rock at a rate of 20 meters per hour. At that rate, 25-and-a-half days of continuous drilling would create the world’s deepest hole.

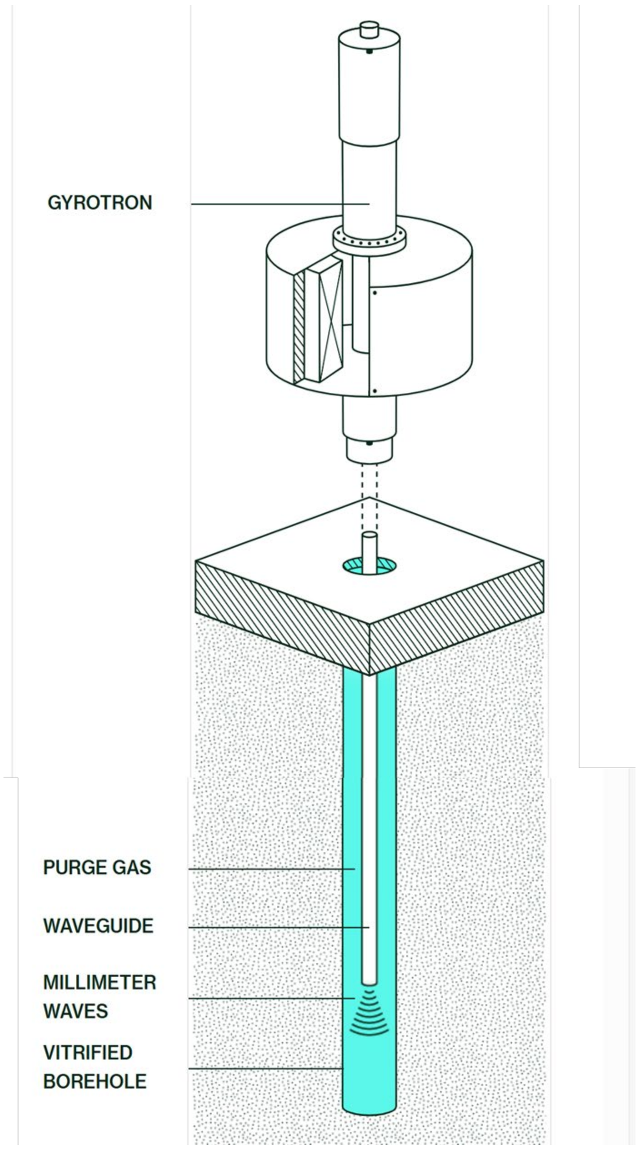
3. Quaise Energy’s Gyrotron

Our gyrotron-powered drilling platform vaporizes boreholes through rock and provides access to deep geothermal heat without complex downhole equipment.[2]

Based on breakthrough fusion research and well-established drilling practices, we are developing a radical new approach to ultra-deep drilling. First, we use conventional rotary drilling to get to basement rock. Then, we switch to high-power millimeter waves to reach unprecedented depths.

On an illustration of the earth, the crust is removed to show a detailed illustration of the core (3486 km, 7000º C), mantle (2885 km, 2000º C), and crust (65 km, 0-1000º C). Magnified areas of the crust appear to show the goals for Quaise's millimeter wave drilling technology: a depth of 20 km and 500º C.

Millimeter wave drilling will unlock the most abundant and powerful clean energy source on Earth by allowing us to drill as far down as 20 km to reach temperatures up to 500° C.



[2] Quaise Energy, Home Page, https://www.quaise.energy/

Carlos Araque spent fifteen years working at one of the world's foremost providers of drilling services to the oil and gas industry. Seeing the negative impacts of that industry firsthand made him want to do something to help make things better. Quaise's deep drilling technology is the result of a decade of research conducted by Paul Woskov at the MIT Plasma Science and Fusion Center.

Aaron Mandell knew both Paul and Carlos and put them all at the table together. Once the first conversation started everyone knew it was a once-in-a-generation idea. Vinod Khosla was the first backer, bringing our ideas to life. Two years later, The Engine, a venture fund built by MIT, led the seed round to help take our technology to market.

4. Current Plan

"We will need about a megawatt to power it, the same amount of energy as a typical drilling rig," says Araque. "But we'll be using it in very different ways. Instead of pumping fluid and turning a drill, we'll be burning and vaporizing rock and extracting gas, which is much easier to pump than mud."[1]

Using the waveguide to direct energy to the targeted rock allows the energy source to stay on the surface. That may sound like a stretch, but the concept was tested in a 1970s experiment in which Bell Labs built a 14 km waveguide transmission medium in northern New Jersey. The researchers found that it could transmit millimeter waves with very little attenuation.

Quaise intends to first target industrial customers with a need for steam at a guaranteed flow rate, temperature, and pressure. "Our goal is to match the specs of an industrial load," says Araque. "They can retire the boiler, and we'll give them 500º C steam on-site."

Eventually, the company hopes the technology could enable new geothermal electric plants, or allow turbines formerly heated by fossil fuels to be repurposed—supplying the grid with an estimated 25-50 megawatts of electricity from each well.

The company plans to begin field demonstrations this autumn, using a prototype device to drill holes in hard rock at a site in Marble Falls, Tex. From there, Quaise plans to build a full-size demonstration rig in a high-geothermal zone in the western United States.

Although laboratory data have demonstrated the feasibility of scaling up the approach, the technical obstacles to the Quaise plan are likely to run deeper than its radical drilling method.

"If they can actually drill a 10 km hole using high-powered microwaves, that will be a significant engineering achievement," says Jefferson Tester, who studies geothermal energy extraction in subsurface rock reservoirs at Cornell University. "But the challenge is completing those wells so they don't fall apart, particularly if you're going to start removing fluids from underground and changing the temperature profile.

"Drilling a hole is challenging enough," says Tester. "But actually running the reservoir and getting the energy out of the ground safely may be something very, very far off in the future."

Final author's comments: So, the real question is: how viable is Quaise Energy, and what are their chances of succeeding?

I will provide some additional information sources and let you decide.

The Team:
https://www.quaise.energy/company

Current time line is near the bottom of their home page:
https://www.quaise.energy/

They have a good news page that is very deep.
https://www.quaise.energy/news

Two final comments for readers that want to dig deeper (pun intended), when you hop from one site to another you frequently find the later wants you to “subscribe,” or at least “register,” to see the content. I avoid this (I get enough junk mail). Where I usually end-up and find good and useful articles is at large news sites, like CNBC, CNN, etc.

There are two types of geothermal resources: hydrothermal and enhanced geothermal. The former already has the three ingredients required for geothermal power: heat, water and permeability. The latter requires some development by either injecting water and/or fracking the rock in the hot zone. From the highlighted text on the prior page, it sounds like the team plans to (at least) start off with hydrothermal resources.