Deep in the Heart of Iceland, There's a New Way to Tap the Earth’s Energy

The Iceland Deep Drilling Project has extended a borehole thousands of meters deep to produce geothermal power at a scale never before seen

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n June 2009, a drill boring thousands of meters into the volcanic rock of northeastern Iceland became unexpectedly stuck. Upon extracting it, researchers discovered it was encased in a glass-like, silica-rich rock called rhyolite. It was solidified magma; the drill had exposed a pocket of magma, deep in the earth, and the magma had cooled, jamming up the drill.

That was the Iceland Deep Drilling Project’s first effort, an exploration of the geology and feasibility of a new kind of geothermal power based on super hot, super compressed liquid found deep underground. Now, more than seven years later, they’re at it again, extending a similar drill even farther beneath the surface of the sparse Reykjanes peninsula on Iceland’s southwest side. Less than two weeks ago, the IDDP-2 reached 3,640 meters in depth, becoming the deepest hole ever drilled in Iceland.

Striking the magma was an accident, explains Wilfred Elders, one of the principal investigators on the IDDP and a professor emeritus of geology at the University of California, Riverside. Aside from damage to the equipment and starting over in a different part of the country, it provided some interesting insight into the type of rock in the region. It even produced power for a short time, and that is the ultimate goal of the project in the first place.

“If we can prove the concept of using supercritical fluids here, this could be done anywhere we can drill to those kind of temperatures and pressures,” says Robert Zierenberg, a professor of geochemistry at the University of California, Davis and another principal investigator.

So in a way, IDDP-2 is a proof of concept. But it’s a big one, with a cost around $15 million, driven by Iceland’s largest power companies, as well as the National Energy Authority of Iceland, and in collaboration with international universities. Already powered entirely by geothermal and hydroelectric energy, the country of 300,000 has seen fit to take a risk on more efficient geothermal—the kind that could, in time, provide a 24/7 complement to the intermittent operations of wind and solar power.

Geothermal, says Bill Glassley, executive director of the California Geothermal Energy Collaborative at the University of California, Davis, has the potential to fuel the whole world, cleanly, indefinitely.

In general, geothermal power is produced by extracting heated water from a deep well, either via steam directly or via a heat exchanger, and using it to drive a turbine. The greater the temperature, the more efficient the system.

“Geothermal power has, up until relatively recently, concentrated on low-hanging fruit,” says Glassley, who has not been involved with the IDDP. “[IDDP is] kind of a preliminary effort to move in the direction of being able to access those much higher temperature resources.”

But for the IDDP, it's not just temperature. At the depths they're drilling, the pressure is so high that the water can't become steam. At high enough temperature pressure—378 degrees Celsius and 220 bar—it becomes a supercritical fluid, with its own properties and a great deal more energy than steam.

"Our modeling indicates that producing supercritical fluid means that we would have a well that could produce an order of magnitude more electric power than a conventional subcritical well," says Elders. That could be up to 50 megawatts, generally described as power for 50,000 homes.

Once the 8.5-inch-diameter drill reaches the target depth of 5,000 meters, they'll find out if the rock has the fractures and water necessary to extract supercritical fluid directly, or whether it will have to be pumped down, a process that gently introduces fractures as the relatively cool water heats up. (It's not at all like fracking, researchers are quick to point out.)

Iceland has been the ideal home for several reasons. The energy companies have been willing to take a risk on a technology that won't pay out right away, says Elders, and the country is already open to, and even reliant on, renewable energy sources. Geographically, the project needed a place where they could drill close to volcanic activity, but (hopefully) avoid hitting actual magma, which, while it contains a lot of energy, can't be used to run a turbine, and would probably wreck the drill anyway. Despite the previous effort, Iceland has been relatively well surveyed, and as it sits on the Mid-Atlantic Ridge, the conditions the drillers are trying to reach lie relatively close to the surface.

There are a handful of other places that could provide suitable sites in the future—unsurprisingly, along other places with volcanoes and seismic activity, like the western U.S., New Zealand, Italy and the East African Rift. But while success in this particular borehole could provide other countries and companies with the confidence they need to start their own projects, there's a lot of work to be done before it starts to produce energy. They have to measure conditions, place a liner in the hole, let it all heat up, test the flow and build a power plant to convert the supercritical fluid to electricity.

"We won't know until we've done it successfully, what the economics might look like. If we succeed in producing a supercritical well at Reykjanes that has sufficient supercritical water to generate the equivalent of 50 megawatts, then we'll have proved the concept," says Elders. "It will take decades to develop that as an industrial process and try it in other parts of the world."