Novel geothermal technology packs a one-two punch against climate change

June 6 2011

Two University of Minnesota Department of Earth Sciences researchers have developed an innovative approach to tapping heat beneath the Earth's surface. The method is expected to not only produce renewable electricity far more efficiently than conventional geothermal systems, but also help reduce atmospheric carbon dioxide (CO2) -- dealing a one-two punch against climate change.

The approach, termed CO2-plume geothermal system, or CPG, was developed by Earth sciences faculty member Martin Saar and graduate student Jimmy Randolph in the university's College of Science and Engineering. The research was published in the most recent issue of Geophysical Research Letters. The researchers have applied for a patent and plan to form a start-up company to commercialize the new technology.

Established methods for transforming Earth's heat into electricity involve extracting hot water from rock formations several hundred feet from the Earth's surface at the few natural hot spots around the world, then using the hot water to turn power-producing turbines. The university's novel system was born in a flash of insight on a northern Minnesota road trip and jump-started with $600,000 in funding from the U of M Institute on the Environment's Initiative for Renewable Energy and the Environment (IREE). The CPG system uses high-pressure CO2 instead of water as the underground heat-carrying fluid.

CPG provides a number of advantages over other geothermal systems,

Randolph said. First, CO2 travels more easily than water through porous rock, so it can extract heat more readily. As a result, CPG can be used in regions where conventional geothermal electricity production would not make sense from a technical or economic standpoint.

"This is probably viable in areas you couldn't even think about doing regular geothermal for electricity production," Randolph said. "In areas where you could, it's perhaps twice as efficient."

CPG also offers the benefit of preventing CO2 from reaching the atmosphere by sequestering it deep underground, where it cannot contribute to climate change. In addition, because pure CO2 is less likely than water to dissolve the material around it, CPG reduces the risk of a geothermal system not being able to operate for long times due to "short-circuiting" or plugging the flow of fluid through the hot rocks. Moreover, the technology could be used in parallel to boost fossil fuel production by pushing natural gas or oil from partially depleted reservoirs as CO2 is injected.

Saar and Randolph first hit on the idea behind CPG in the fall of 2008 while driving to northern Minnesota together to conduct unrelated field research. The two had been conducting research on geothermal energy capture and separately on geologic CO2 sequestration.

"We connected the dots and said, 'Wait a minute – what are the consequences if you use geothermally heated CO2?'" recalled Saar. "We had a hunch in the car that there should be lots of advantages to doing that."

After batting the idea around a bit, the pair applied for and received a grant from the Initiative for Renewable Energy and the Environment, which disburses funds from Xcel Energy's Renewable Development Fund to help launch potentially transformative projects in emerging

fields of energy and the environment. The IREE grant paid for preliminary computer modeling and allowed Saar and Randolph to bring on board energy policy, applied economics and mechanical engineering experts from the University of Minnesota as well as modeling experts from Lawrence Berkeley National Laboratory. It also helped leverage a $1.5 million grant from the U.S. Department of Energy to explore subsurface chemical interactions involved in the process.

"The IREE grant was really critical," Saar said. "This is the kind of project that requires a high-risk investment. I think it's fair to say that there's a good chance that it wouldn't have gone anywhere without IREE support in the early days."

Saar and Randolph have recently applied for additional DOE funding to move CPG forward to the pilot phase.

"Part of the beauty of this is that it combines a lot of ideas but the ideas are essentially technically proven, so we don't need a lot of new technology developed," Randolph said.

"It's combining proven technology in a new way," Saar said. "It's one of those things where you know how the individual components work. The question is, how will they perform together in this new way? The simulation results suggest it's going to be very favorable."

Provided by University of Minnesota