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ENERGY

How One Country Is Making Rocks Out of Air Pollution

Iceland's volcanic formations offer a new possibility for trapping carbon emissions.

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Iceland's Hellisheidi geothermal plant is the site of groundbreaking work on capturing carbon.

PHOTOGRAPH BY JONAS BEHNDIKSEN, NATIONAL GEOGRAPHIC CREATIVE

By **Christina Nunez**

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At a power plant in Iceland, volcanic rock is being used to transform carbon dioxide into salt-like crystals. Underground, the greenhouse gas becomes solid in a matter of months, mimicking a natural process that can take centuries.

The research, detailed Thursday in the journal *Science*, is part of a larger quest to capture carbon at power plants and then store it underground. Solidifying the carbon could reduce the risk of it leaking out into the atmosphere, contributing to climate change.

At the Hellisheidi geothermal plant near Reykjavik, researchers dissolve carbon dioxide in water and inject it into basalt rock, which chemically reacts with the gas, mineralizing it. The project, dubbed [Carbfix](#), began in 2007.

"The conventional wisdom has been that these reactions would be slow," says Martin Stute, adjunct senior research scientist at Columbia University and a lead author of the paper. "They would take 100 years, maybe a thousand."



The carbon injection site at the Hellisheidi complex.

PHOTOGRAPH COURTESY OF MARTIN STUTE

At Hellisheidi, the process took less than two years. The researchers used chemical tracers to monitor the CO₂ in wells dug between 400 and 1,300 meters (1,312 to 4,265 feet) down, then verified the results by bringing up samples of the rock. They saw it was covered with the whitish, crystallized carbon—95 percent of what was injected had turned to stone.

"It's really exciting news," says Pete McGrail, a scientist at Pacific Northwest National Lab who also studies [carbon sequestration](#). He says the Carbfix field results confirm years of lab tests that suggested carbon dioxide could mineralize fairly rapidly.

Hellisheidi is Iceland's largest geothermal plant, tapping the country's vast reserves of subterranean volcanic warmth to generate electricity and heat. Though the energy is renewable, it isn't totally free of carbon—or odors: Water pumped from underground brings up not only carbon dioxide but hydrogen sulfide, a corrosive gas that smells of rotten eggs.



Scientists capture the carbon emissions by binding it to basalt rocks.

PHOTOGRAPH COURTESY OF KEVIN KRAJICK/LAMONT-DOHERTY EARTH OBSERVATORY

The plant's annual carbon emissions—40,000 tons—amount to 5 percent of those from a comparable coal-fired facility, [according to plant operator](#) Reykjavik Energy, but the company was also under government pressure to remove the sulfurous gas.

The need to deal with the sulfur smell is what made the project feasible, paper co-author and Reykjavik Energy Project Manager Edda Sif Aradottir acknowledged [last year](#). "If you look at other projects worldwide, the ones that are successful have some kind of added value like this—otherwise it's hard to justify," she said.

Aradottir was referring to the cost, which can be prohibitive for many carbon capture projects. Because the Iceland plant already had to build the infrastructure to extract waste gases, the cost to store the carbon was "only \$30 a ton," according to Aradottir.

Similar projects could cost more than triple that amount, which is why facilities such as Canada's \$1.1 billion [Boundary Dam project](#) use the captured CO₂ to goose production at oil wells rather than simply storing it. Even then, the technology is new, and projects such as Boundary Dam and Mississippi Power's Kemper County plant have suffered financial and technical woes while trying to make coal power cleaner.



Basalt underlies 90 percent of Iceland and has the ability to store carbon, scientists show.

PHOTOGRAPH COURTESY OF KEVIN KRAJICK/LAMONT-DOHERTY EARTH OBSERVATORY

Aside from the cost concerns, researchers on Carbfix also note that it uses a lot of water: 25 tons for every ton of sequestered carbon dioxide.

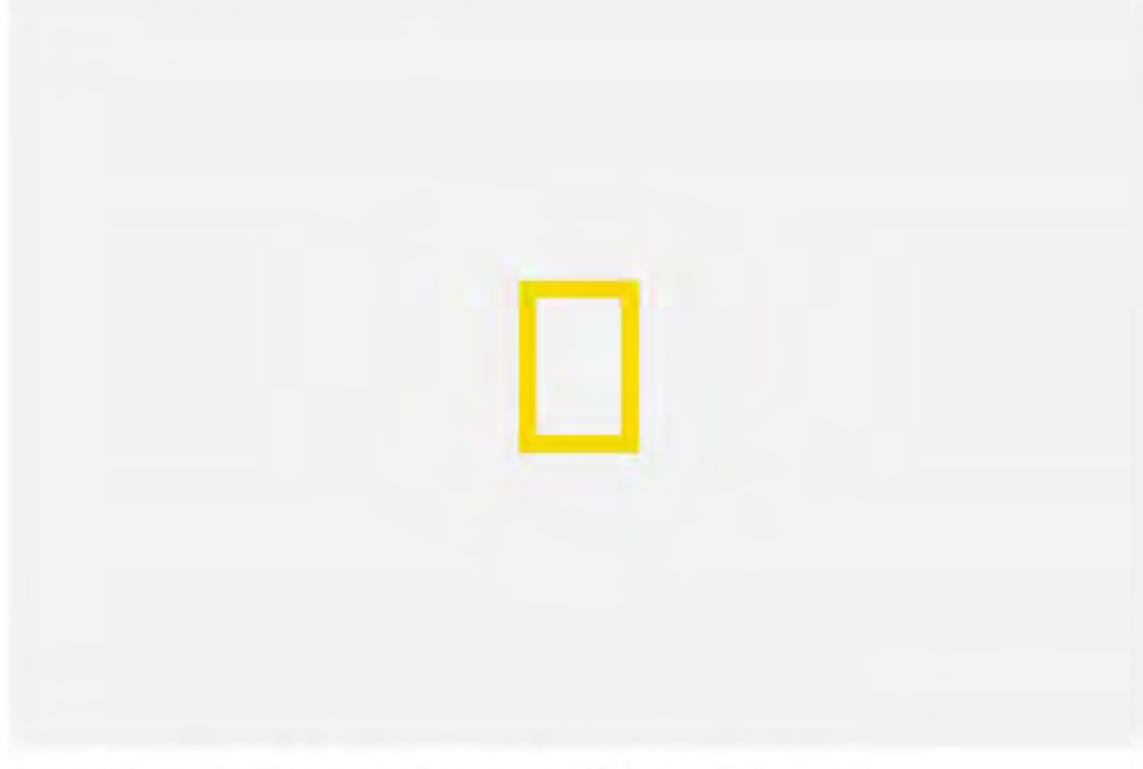
"Using so much water in the process is a downside of this technology," Stute acknowledges, but he adds that some or all of the water could be recycled. Seawater, as opposed to geothermal wastewater, might also be used, he says: "There's no obvious indication why it shouldn't work, but I think that definitely has to be studied."

McGrail also notes it's not yet clear whether carbon solidification can reach commercial scale. "There remains some important work that's still to be done," he says, raising questions over how long wells could remain injectable and how just how much carbon could be put away.

The Carbfix pilot initially injected 250 tons of gas (mostly carbon dioxide with some hydrogen sulfide mixed in). Stute says the Hellisheidi plant has already scaled up to a rate of 5,000 tons annually; the goal is to eventually sequester all of its emissions. Though triggering earthquakes is a risk, Stute says it hasn't happened at Hellisheidi, and "one has to know the site quite well" to ensure it has the properties to accommodate injections.

Basalt is so common worldwide that, in theory at least, there's enough of it to absorb the world's carbon emissions. In reality, the economics and geology have to work. In terms of possibilities for reducing carbon emissions from fossil fuels, McGrail says, using basalt storage "gives you another arrow in your quiver."

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Pipes convey steam to the geothermal plant to generate power.

PHOTOGRAPH COURTESY OF MARTIN STUTE

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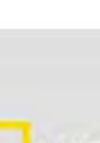
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