Storage project turns CO_2 into stone

Umair Irfan, Environment and Energy Publishing, 3-5-12

In a new experiment, Iceland is looking to replace its smokestacks with well injectors to permanently sequester its carbon dioxide emissions.

Researchers are now pumping CO_2 underground in a process that will convert the greenhouse gas into rock. This technique may be a model for other power plants and factories to control their emissions, creating a climate change solution literally set in stone.

"Carbon dioxide capture and storage is important because we depend on fossil fuels, and we will depend on fossil fuels for the next 50 to 100 years," said Juerg Matter, a professor of geochemistry at Columbia University.

"This is bad news for global climate change, especially greenhouse gases in the atmosphere. In terms of climate change, we have to decarbonize our energy infrastructure," he added.

The CarbFix pilot program aims to resolve this problem by capturing carbon dioxide from the Hellisheiði Power Station, Iceland's largest geothermal heat and energy facility and the second-largest in the world.

The 300-megawatt plant taps heat and gas pockets up to 1.2 miles below the surface to drive seven turbines. In the process, Hellisheiði releases steam, which makes up roughly 99.5 percent of its emissions. The rest is mostly carbon dioxide, along with small amounts of hydrogen sulfide, argon and methane.

Matter, who works with the program, said CarbFix is the first system that injects carbon dioxide into basalt, a form of volcanic rock. "The capacity of these rocks, the storage capacity, could be very large," he said.

Waste carbon dioxide is first separated from steam and then dissolved in water, forming carbonic acid. The solution is then pumped 550 yards underground into a basalt formation, where the acidity leaches elements like calcium and magnesium from the surrounding rocks. Over time, the solution flows through the basalt formation and these elements recombine to form minerals like limestone.

Iceland makes an ideal test site because the ground beneath the island nation is 90 percent basalt, which is formed by volcanic activity. The country also generates most of its electricity from geothermal sources.

However, CarbFix is not without its challenges. The project's current phase injects carbon dioxide from a nearby geothermal well instead of the generation plant. Though the project started in 2007, the team only started injecting the well in January and will begin to inject from the geothermal plant itself in April.

"We assumed that the main difficult part of the experiment would be injecting the gas. Instead, we are delayed by the gas separation stage," explained Edda Aradóttir, the project manager for CarbFix. "It has turned out to be a much more complex task than we thought."

The hydrogen sulfide proved very troublesome because it corroded the hardware and formed compounds that hampered the processing equipment when it was separated from the steam. The current phase injects only carbon dioxide, while the next phase will also inject hydrogen sulfide into the basalt.

Other issues included developing new instruments and techniques to monitor rock formations deep underground, said Aradóttir. The team also had to engineer a system to transport the carbon dioxide from the sources to the injection well.

The whole process is also resource-intensive, requiring large amounts of water and electricity. The carbon dioxide may also take anywhere from a few months to a few years to be converted fully to stone. "This kind of experiment is very expensive," admitted Aradóttir. "We're not at the commercial stage yet."

Still, the idea has immense potential. Basalt formations are found in many parts of the world, and the CarbFix site can store billions of tons of carbon dioxide, Matter said. Unlike other forms of carbon storage, waste gases can be converted to stone at relatively shallow depths, the leakage risk is minimal and the results are permanent.

In addition, CarbFix is already showing results. Matter observed that the acidic solution is being neutralized underground, indicating that the rock-forming reaction is taking place. "If it's mineralized within a human lifetime, then we know we are on a successful pathway," he said. As the technology improves and the costs come down, Matter thinks sequestering carbon dioxide in basalt could become a viable strategy for controlling greenhouse gas emissions.

Proof of permanent storage could ease some of carbon capture's commercial problems. One of them is obtaining insurance coverage, because insurers are concerned about the long-term financial risks of storing carbon dioxide in a gaseous or liquid form underground, which include the possibility of leakage.