A hole in the ground: Storing carbon dioxide thousands of feet below Illinois

By Maggie Koerth-Baker at 6:00 am Friday, Dec 2

One blazing hot afternoon in August of 2010, I stood on a mountain top in Alabama, staring at a styrofoam beer cooler upended over the top of a metal pole. Alongside me were a couple dozen sweaty engineers and geologists. That beer cooler was one of the few visible signs of the research project happening far below our feet.

Over the course of two months, scientists from the University of Alabama had injected 278 tons of carbon dioxide into the Earth. The goal was to keep it there forever, locked in geologic formations. The beer cooler was a key part of that plan. Beneath it sat the delicate electronic components of the monitoring system the scientists were using to make sure none of the captured carbon dioxide found its way out of the mountain. Beer coolers, it turns out, make great low-cost heat protection.

Carbon capture and storage—the process of removing carbon dioxide from factory and power plant emissions and trapping it where it can't reach the atmosphere—is an interesting idea.

It has the potential to help us make our current energy systems cleaner as we work on building more sustainable systems for the future. With that in mind, the Department of Energy has seven regional research teams testing carbon capture and storage at sites around the United States.

So far, nobody in the United States has put this full process to the test at the scale that would be necessary in the real world. But, in the past couple of weeks, scientists at the Midwest Geological Sequestration Consortium began pumping carbon dioxide at a new site, one that is going to give us our best picture yet of what full-scale carbon capture and storage (CCS) will be like.

Two hundred and seventy-eight tons might sound like a lot of carbon dioxide. It's not. An average-sized coal power plant will produce 3 million metric tons of CO2 in a year. The infrastructure used at the Alabama site I visited can't be easily scaled up to meet a need like that.

More important, the Alabama project didn't test out the full CCS process. The carbon dioxide stored there didn't come from man-made sources. At least, not like we think of them. Instead, it's naturally occurring CO2, collected by breaking down carbonate rocks. This CO2 is sold for industrial purposes. It's used in some advanced oil and gas recovery techniques. It makes your soda fizzy. And, with exactly two exceptions, it's been the CO2 that's been stored at carbon capture and storage research sites. The Alabama scientists bought CO2, trucked it across the country, compressed it, and pumped it into a hole in the ground.

That sounds a little ridiculous. But there aren't a lot of other options. Big talk and PR aside, the vast majority of coal fired power plants in the United States don't remove carbon dioxide from their emissions. There's no financial incentive to make them want to take on the investment of installing the right equipment.

The new Midwestern carbon storage site, near Decatur, Illinois, is different. First, it's one of the biggest projects ever


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undertaken. Over the next three years, 1 million metric tons of carbon dioxide will be pumped into rock formations underground. There's only one other site in the country operating at that scale.

Next, the Midwestern site will be the second project, ever, to store carbon dioxide drawn from an actual energy-producing factory. The first, in West Virginia, was much, much smaller. This makes a big difference in how the project operates. Instead of trucking CO2 in from out of state, the carbon dioxide buried beneath Decatur will arrive in a pipeline, sent from a nearby ethanol refinery.

It's not quite the scale of a real-world CCS system. But this is how a real-world system would work. For the first time, instead of just looking at individual parts, we're going to see the whole thing in action.

How It Works

You take carbon dioxide and you pump it into a hole in the ground. That's the fast explanation. But, in reality, carbon capture and storage is really not that flippant.

For one thing, it's not just any old hole in the ground.

Robert Finley, director of the Advanced Energy Technology Initiative at the Illinois State Geological Survey and one of the scientists working on the Decatur project, says the process of choosing the site began in 2003 with a survey of the entire Illinois Basin. The final site was chosen because of specific geologic features that make it naturally conducive to storing compressed gas.

At Decatur, compressed CO2, in the form of a liquid-like supercritical fluid, is sent down a pipe 7000 feet below ground to a layer of porous sandstone called Mt. Simon Sandstone. The supercritical fluid flows into those pores mingling with and displacing the brine that exists there naturally. If there were nothing but sandstone, you could expect the CO2 to travel back up and out of the Earth. However, above the sandstone sits a caprock. Three caprocks, actually. They're all made from impermeable shale. The sandstone gives the CO2 a place to sit, the shale keeps it there. It's the same kind of features that hold natural gas deposits in place for millions of years.

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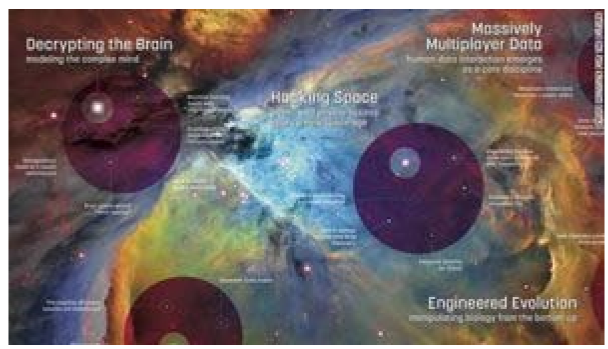

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The CO2 will sit there for somewhere between a few hundred and a few thousand years, Finley says, until it mineralizes. Essentially, it will become the same kind of rock that's broken down today to make the CO2 stored beneath Alabama.

What Are the Risks?

This is where carbon capture and storage gets complicated.

Physically, the risks are not massive, but they do exist. These storage systems are based on how nature stores gas and liquids. They use the same geologic rules. Finley says that you can almost think of it as drilling for oil and natural gas in reverse. Instead of pumping stuff out of these natural reservoirs, we're pumping stuff into them.

It is not common to find natural reservoirs in the United States that have failed, he says. Jed Clampett aside, oil and gas are normally discovered via lots of digging, not because somebody ran across a spot where the oil or gas was seeping out of the Earth. But while it might not be common, it does happen. Western New York state, for instance, is home to multiple "eternal flames," spots where natural gas has escaped its geologic prison and made it to the surface.

The Decatur site was chosen partly because it provides a good opportunity to catch a leak like that before it could do any damage. The carbon dioxide is being stored at 7000 feet underground. The useable groundwater sits at 150 feet down. In between are the caprocks and, at 5500 feet—just above the first caprock—there's a monitoring system, watching for signs of leaks.

So what happens if and when a carbon storage site springs a leak? The primary concerns are really A) groundwater quality and B) that you've just wasted a lot of money capturing and storing carbon dioxide that's now leaking back into the atmosphere.

Most researchers don't think a leak from a reservoir is likely to cause any loss of life. There's a reason for that. When you think, "Carbon dioxide disaster," you probably think about Lake Nyos. In 1986, this volcanic lake essentially burped, releasing a huge bubble of carbon dioxide from the lake bottom that asphyxiated humans and animals for miles around. That's not the kind of leak you get from underground reservoirs. Think of it as the difference between a balloon popping and a balloon slowly deflating over the course of a week. Those natural gas seeps in New York aren't killing people.

When scientists worry about dangerous carbon dioxide leaks from CCS sites, they worry about the piping. If the pipeline going down a well were to catastrophically fail, and if the flow of gas wasn't turned off, and if the prevailing winds and local surface geography were *just* right, you could, conceivably, end up with a potentially deadly cloud of CO2. This is the point where reasonable people have room to disagree. Some, including Robert Finley, look at all those "ifs" and see an extremely unlikely scenario that can be avoided by good planning and site selection. But not everybody is going to be comforted by that.

Honestly, though, I think the biggest problem with CCS isn't so much physical as it is ideological. The risk is that carbon capture and storage could be pushed as THE solution to our energy problems. And it really, really isn't.

There are a lot of reasons for that, but chief among them is the fact that there is not an unlimited supply of good sites for storing captured CO2. The Decatur site could take a lot more than 1 million metric tons. Finley says there's room for 10s of millions of tons down there. And there are lots of potential sites scattered across the United States. But there are more than 400 coal-fired power plants in the country, as well, each producing several million tons of CO2 per year. Carbon capture and storage is not a license to go on using coal indefinitely. Likewise, there are some parts of the country where finding a good site is going to be difficult. New England, for instance, is sitting on top of a lot of non-porous granite, Finley says.

Think of CCS like a Prius hybrid. It's a cleaner car to drive than, say, a 1978 Impala. Back in 2000, it was really your only choice if you wanted a car and you wanted it to be cleaner. Hybrid cars are a nice way to bridge the gap between all-gas and all-electric. But they aren't the endgame. If we want a more sustainable future, we eventually have to replace the hybrids completely. Same thing here.

Meanwhile, while we're controlling that risk, there's also a risk that you could have a perfectly workable CCS system that never gets used at a commercial scale, leaving dirty coal plants that dirty when they could be a lot cleaner. Why hasn't this technology been used at full-scale yet? It's complicated, but the biggest reason is that there haven't been a lot of companies interested in doing that.

It's telling that Finley gives props to Archer Daniels Midland, the company that owns the ethanol plant, for being interested in working on this project at all and for providing CO2 free of charge. In the past, they've sold that CO2 to make soda and dry ice. Clean coal is an industry buzzword, but it's rare to find coal plants that want to make that happen immediately. About the only place is in Texas' Permian Basin, where some soon-to-be-built power plants have been sited near oil and gas drilling operations, with the goal of selling CO2 to the fossil fuel industry for advance recovery operations.

Industry doesn't have much interest in CCS. And it won't, Finley says, until there's a price on carbon dioxide emissions. That's the thing that will incentivize companies into capturing their carbon. Until then, carbon capture and storage is likely to remain the domain of scientists, something that happens in demonstration projects, but not in the real world.

Image: A flexible tube for carrying CO2 at Germany's "Schwarze Pumpe" power plant. This small demonstration project, which came online in 2008, is the first power plant in the world to remove carbon emissions from its exhaust and bury them in the ground. REUTERS/Hannibal Hanschke

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