Researchers examine carbon capture and storage to combat global warming

June 11 2007

While solar power and hybrid cars have become popular symbols of green technology, Stanford researchers are exploring another path for cutting emissions of carbon dioxide, the leading greenhouse gas that causes global warming.

Carbon capture and storage, also called carbon sequestration, traps carbon dioxide after it is produced and injects it underground. The gas never enters the atmosphere. The practice could transform heavy carbon spewers, such as coal power plants, into relatively clean machines with regard to global warming.

"The notion is that the sooner we wean ourselves off fossil fuels, the sooner we'll be able to tackle the climate problem," said Sally Benson, executive director of the Global Climate and Energy Project (GCEP) and professor of energy resources engineering. "But the idea that we can take fossil fuels out of the mix very quickly is unrealistic. We're reliant on fossil fuels, and a good pathway is to find ways to use them that don't create a problem for the climate."

Carbon capture has the potential to reduce more than 90 percent of an individual plant's carbon emissions, said Lynn Orr, director of GCEP and professor of energy resources engineering. Stationary facilities that burn fossil fuels-such as power plants or cement factories-would be candidates for the technology, he said.

Capturing carbon dioxide from small, mobile sources, such as cars, would be more difficult, Orr said. But with power plants comprising 40 percent of the world's fossil fuel-derived carbon emissions, he added, the potential for reductions is significant.

Not only can a lot of carbon dioxide be captured, but the Earth's capacity to store it is also vast, he added.

Estimates of worldwide storage capacity range from 2 trillion to 10 trillion tons of carbon dioxide, according to the Intergovernmental Panel on Climate Change (IPCC) in its report on carbon capture and storage. Global emissions in 2004 totaled 27 billion tons, according to the U.S. Department of Energy's Energy Information Administration.

If all human-induced emissions were sequestered, enough capacity would exist to accommodate more than 100 years' worth of emissions, according to Benson, coordinating lead author of the IPCC chapter on underground geological storage.

With fossil fuels already comprising 85 percent of the world's energy consumption, and their use rapidly increasing due to the growth of developing countries, such as China and India, the need to find solutions to curb carbon emissions becomes even more crucial, Benson said.

From the air to the earth

In the capture process, carbon dioxide is extracted from a mix of waste gases. The most common method sends the exhaust through a chimney containing a three-dimensional mesh. As the gas goes up, a chemical solvent drizzles down, soaking up the gas where the two substances meet. The carbon dioxide is then extracted from the liquid and compressed, now ready for storage.

The best storage options today lie in geologic sequestration-storage in old oil fields, natural gas reservoirs, deep saline aquifers and unminable coal beds, hundreds to thousands of meters underground.

The carbon dioxide is pumped down through wells, like those used to extract oil, and dissolves or disperses in its reservoir.

Viable locations must have a caprock, or an impermeable layer above the reservoir shaped like an upside-down bowl, that traps the gas and keeps it from escaping, the researchers said.

Safety smarts

"The goal of carbon sequestration is to permanently store the carbon dioxide," Benson said, "permanent meaning very, very long-term, geological time periods."

The greatest concern surrounding carbon dioxide storage is the potential for it to leak, researchers said.

The most obvious worry, said Benson, is that leakage would lead to more global warming, defeating the purpose of storage in the first place.

"People think, it would have been sort of sad going through all this trouble," said Tony Kovscek, associate professor of energy resources engineering and a researcher on a GCEP project on carbon sequestration in coal.

But studies have shown that leakage, if it happened at all, would be insignificant, Benson said. The IPCC reported that 99 percent retention of the carbon dioxide that is stored would be "very likely" over 100 years and "likely" over 1,000 years, she said.

"If you do it right, if you select the site correctly and monitor, it can be near permanent," Benson said.

Of greater concern to the researchers are the potential risks of carbon sequestration to human health, mainly through asphyxiation and groundwater contamination.

The threat of asphyxiation-or suffocation due to carbon dioxide displacing oxygen-is very low, the researchers said, because of the unlikelihood of a rapid leakage, which would have to occur to cause a problem.

Drinking water contamination, Benson said, is the more probable danger. For example, if carbon dioxide enters the groundwater somehow, it can increase the water's acidity, potentially leaching toxic chemicals, such as lead, from rocks into the water, she said.

To address these risks, scientists are studying reservoir geology to better understand what happens after injecting carbon dioxide underground.

"You need to carefully select places that won't leak, and do a good job of engineering the injection systems and paying attention to where the carbon dioxide is actually going," Orr said.

While a thorough technical understanding of the risks will reveal best practices, the scientists also stressed the need for good management to see that proper procedures are followed.

Benson points to a familiar technology as a model for thinking about and tackling risk.

"People often ask, is geological storage safe" It's a very difficult question to answer. Is driving safe"" she expounded. "You might say yes or no, but what makes driving something we're willing to do" You get automakers to build good cars, we have driver training, we don't let children drive, we have laws against drunk driving-we implement a whole system to ensure that the activity is safe."

Policy and progress

Engineers have more than three decades of experience putting carbon dioxide into oil reservoirs, where it increases oil production by making the oil expand and "thin out" such that it flows more easily, Benson said.

"That experience gives us confidence that we know how to drill the wells, push the [carbon dioxide] in and say something about what will happen when it gets down there," said Orr.

Currently, three industrial-scale projects are pumping millions of tons of carbon dioxide into the ground every year. Two of them represent the first efforts at storage in deep saline aquifers.

A Stanford team also has begun researching storage of carbon dioxide in deep coal beds. In coal, chemical bonds form between the carbon dioxide and the coal, making the method potentially more secure than others, the researchers said.

Even better, the process can free natural gas that sits on the coal's surface. Natural gas is a relatively clean fossil fuel, which can then be burned in place of coal, said Mark Zoback, professor of geophysics and a researcher on the project on storage in coal.

The project, which is funded by GCEP and GEOSEQ-a partnership involving the Department of Energy, several national labs, government groups and industry partners-is still in its early stages, the researchers said.

Of all the projects, only one is turning a profit without recovering oil. Sleipner, an industrial-scale project run by Norwegian oil company Statoil, injects carbon dioxide into a deep saline aquifer beneath the North Sea floor.

Its economic success, scientists say, is due to the presence of Norway's high carbon taxes, which give green technologies an advantage by discouraging carbon emissions.

Carbon taxes are charged to a company for every ton of carbon dioxide it emits, so that it becomes increasingly costly to be dirty. Thus the taxes encourage companies to be green.

When a clean technology is expensive-incorporating carbon capture and storage into a power plant costs $30 to $70 per ton of carbon dioxide-taxes on emissions level the playing field and help make it viable.

A policy framework, therefore, is essential for making carbon capture and storage economical, the Stanford researchers said.

"We need thousands of projects," Benson said. "That's the kind of thing that will only happen if there are global policies to address these issues. That's the number one critical thing."

With the proper development, Benson believes that carbon sequestration could be ripe for industry in the next 20 years.

'A family of solutions'

Critics of carbon sequestration argue that the technology will divert attention from research on long-term clean energy options, such as renewable power. Worse, they fear it will prolong fossil fuel use, if fossil fuels from some stationary sources can be used more cleanly.

But the researchers continually emphasize the need to adopt other technologies in addition to carbon sequestration.

"Geological sequestration is going to be one of a family of solutions for addressing the greenhouse gas issue," said Zoback.

Energy efficiency and renewable energy are already feasible today and also can define the long-term energy picture, he said.

"[Carbon dioxide] sequestration, on the other hand, is only a bridge technology," he added. "Maybe we have another hundred years of using fossil fuels, and then we'll be on to better and smarter things, one hopes. If we're going to be creating greenhouse gases for another hundred years, it's a huge problem right now, so you have to get on this point. But nonetheless, our dependence on fossil fuels is not going to last forever."

Source: Stanford University

Citation: Researchers examine carbon capture and storage to combat global warming (2007, June 11) retrieved 27 April 2024 from https://phys.org/news/2007-06-carbon-capture-storage-combat-global.html