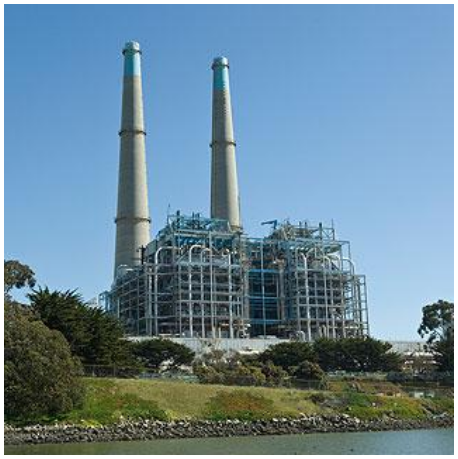
August 7, 2008 | 49 comments

Cement from CO_2: A Concrete Cure for Global Warming?

A new technique could turn cement from a source of climate changing greenhouse gases into a way to remove them from the air

By David Biello



CLIMATE CHANGE CURE?: By running the flue gas from Moss Landing's mammoth smokestacks through ocean water, a new company can make cement from carbon dioxide pollution. COURTESY OF DYNEGY

E-MAIL PRINT COMMENT

The turbines at Moss Landing power plant on the California coast burn through natural gas to pump out more than 1,000 megawatts of electric power. The 700-degree Fahrenheit (370-degree Celsius) fumes left over contain at least 30,000 parts per million of carbon dioxide (CO_2)—the primary greenhouse gas responsible for global warming—along with other pollutants.

Today, this flue gas wafts up and out of the power plant's enormous smokestacks, but by simply bubbling it through the nearby seawater, a new California-based company called Calera says it can use more than 90 percent of that CO_2 to make something useful: cement.

It's a twist that could make a polluting substance into a way to reduce greenhouse gases. Cement, which is mostly commonly composed of calcium silicates, requires heating limestone and other

ingredients to 2,640 degrees F (1,450 degrees C) by burning fossil fuels and is the third largest source of greenhouse gas pollution in the U.S., according to the U.S. Environmental Protection Agency. Making one ton of cement results in the emission of roughly one ton of CO_2—and in some cases much more.

While Calera's process of making calcium carbonate cement wouldn't eliminate all CO_2 emissions, it would reverse that equation. "For every ton of cement we make, we are sequestering half a ton of CO_2," says crystallographer Brent Constantz, founder of Calera. "We probably have the best carbon capture and storage technique there is by a long shot."

Carbon capture and storage has been identified by experts ranging from the U.N.'s Intergovernmental Panel on Climate Change to the leaders of the world's eight richest nations (G8) as crucial to the fight against climate change. The idea is to capture the CO_2 and other greenhouse gases produced when burning fossil fuels, such as coal or natural gas, and then permanently store it, such as in deep-sea basalt formations.

Calera's process takes the idea a step forward by storing the CO_2 in a useful product. The U.S. used more than 122 million metric tons of Portland cement in 2006, according to the Portland Cement Association (PCA), an industry group, and China used at least 800 million metric tons.

The Calera process essentially mimics marine cement, which is produced by coral when making their shells and reefs, taking the calcium and magnesium in seawater and using it to form carbonates at normal temperatures and pressures. "We are turning CO_2 into carbonic acid and then making carbonate," Constantz says. "All we need is water and pollution."

The company employs spray dryers that utilize the heat in the flue gas to dry the slurry that results from mixing the water and pollution. "A gas-fired power plant is basically like attaching a jet engine to the ground," Constantz notes. "We use the waste heat of the flue gas. They're just shooting it up into the atmosphere anyway."

In essence, the company is making chalk, and that's the color of the resulting cement: snow white. Once dried, the Calera cement can be used as a replacement for the Portland cement that is typically blended with rock and other material to make the concrete in everything from roads to buildings. "We think since we're making the cement out of CO_2, the more you use, the better," says Constantz, who formerly made medical cements. "Make that wall five feet thick, sequester CO_2, and be cooler in summer, warmer in winter and more seismically stable. Or make a road twice as thick."

Of course, Calera isn't the only company pursuing this idea—just the most advanced. Carbon Sciences in Santa Barbara, Calif., plans to use flue gas and the water leftover after mining operations, so-called mine slime, which is often rich in magnesium and calcium, to create similar cements. Halifax, Nova Scotia–based Carbon Sense Solutions plans to accelerate the natural process of cement absorbing CO_2 by exposing a fresh batch to flue gas. And a number of companies are working on reducing the energy needs of Portland cement making. The key will be ensuring that such specialty cements have the same properties and the same or lower cost than Portland cement, says Carbon Sciences president and CEO Derek McLeish.

But the companies may also find it challenging to get their cements approved by regulators and, more importantly, accepted by the building trade, says civil engineer Steven Kosmatka of the Portland Cement Association. "The construction industry is very conservative," he adds. "It took PCA about 25 years to get the standards changed to allow 5 percent limestone [in the Portland cement mix]. So things move kind of slowly."

Calera hopes to get over that hurdle quickly by first offering a blend of its carbon-storing cement and Portland cement, which would not initially store any extra greenhouse gases but would at least balance out the emissions from making the traditional mortar. "It's just a little better than carbon neutral," notes Constantz, who will make his case to the industry at large at the World of Concrete trade fair in February. "That alone is a huge step forward."

"Could you take this calcium carbonate and add it to Portland cement? You sure can," Kosmatka says. "Could you add it to the ready mix to replace some of the Portland cement? You probably can do that, too." That would help to rein in the greenhouse gas emissions from buildings—both from building them and powering them once they are built—that makes up 48 percent of U.S. global warming pollution.

Nor are there any limitations on the raw materials of the Calera cement: Seawater containing billions of tons of calcium and magnesium covers 70 percent of the planet and the 2,775 power plants in the U.S. alone pumped out 2.5 billion metric tons of CO_2 in 2006. The process results in seawater that is stripped of calcium and magnesium—ideal for desalinization technologies—but safe to be dumped back into the ocean. And attaching the Calera process to the nation's more than 600 coal-fired power plants or even steel mills and other industrial sources is even more attractive as burning coal results in flue gas with as much as 150,000 parts per million of CO_2.

But Calera is starting with the cleanest fossil fuel—natural gas. The company has set up a pilot plant at Moss Landing because California is soon to adopt regulations limiting the amount of CO_2 power plants and other sources can emit, and natural gas is the primary fuel of power plants in that state. According to Constantz, some flue gas is already running through the company's process. "We are using emissions from gas-fired generation as our CO_2 source at the pilot plant where we are making up to 10 tons a day," he says. "That material will be used for evaluations."

The California Department of Transportation (Caltrans) has expressed interest in testing the cement, and Dynegy, owner of the Moss Landing power plant, is also intrigued. Although no formal agreement has been struck, "their proposed technology for capturing CO_2 from flue gases and turning it into a beneficial, marketable product sounds very interesting to us," Dynegy spokesman David Byford says. "There are very good technologies for capturing the emissions of other pollutants. The carbon issue is something we are just turning our attention to now, and so far it's been quite elusive."