**The Challenges of Carbon Captureand Sequestration**

As the concern over levels of carbon dioxide (CO2) in the atmosphere increase, so does the research. One area of study that’s gaining attention is the ability to capture carbon before it escapes into the atmosphere and storing it safely underground. There’s no better place to capture carbon than at a fixed source, like a fossil fuel power plant. And with Florida’s saline aquifers, the state looks to be candidate for carbon storage.

Mark Stewart, a professor in the Geology Department at the University of South Florida (USF), is the principal investigator on a research project that’s investigating the efficacy of capturing carbon at fixed sources and sequestering it in the carbonate rocks that run thousands of feet deep beneath Florida’s ground surface.

Stewart emphasizes that the project is truly a team effort, with each member bringing their expertise to the table.

“I may be the lead for the CO2 sequestration research in Florida for FESC, but it wouldn’t work without collaborators,” says Stewart.

**Capturing the Carbon**

The project comprises various aspects of the capturing and storage process. The removal of carbon from the flue gas is often the most complicated component of the process. For this element, Stewart relies on Yogi Goswami, professor of Chemical Engineering at USF and Co-Director of the Clean Energy Research Center.

Goswami’s research involves developing more effective and economic ways to capture CO2 from flue gas. Technologies include the use of solvents, sorbents, membranes, and cryogenic separation. One method of particular interest utilizes ceramic cloth impregnated with a thin film of calcium or calcium-magnesium oxide. As the flue gas passes through, the carbon is captured by converting the oxide to carbonate. With the carbon secured, flue gas, sans CO2, escapes. Heating the ceramic converts the carbonate back to the oxide, driving off the CO2 and making it available for sequestration in a more concentrated stream. The thin film technology for carbon capture is in the patent process and ready for licensing by the USF office of Patents and Licensing.

“It’s an on-off cycle,” explains Stewart. “It’s not easy to capture CO2 and then it requires a lot of energy to separate it. It’s possible to use the flue gas to heat the ceramic.”

Goswami’s research is also focusing on increasing the thermal efficiency of the system and extending the life of the thin oxide film, in hopes of making the solid sorbent technology more cost effective and scalable.

**Going underground**

Once the carbon is captured, the next challenge is how to most effectively transfer it to Florida’s deep saline aquifers for storage. Both the physical and chemical aspects of injecting carbon into the subsurface must be considered. With Stewart’s background in geophysical and mathematical modeling, his role is to evaluate the physical aspects of CO2 storage.

“We use a model developed by the Department of Energy (DOE), TOUGH, that has the capability of simulating the behavior of three-phase systems, gas, liquid, and dissolved gas,” says Stewart.

Data was gathered from the Florida Geologic Survey for the study area, the Cedar Key-Lawson formation, located in the lower half of the peninsula. This location was selected as it’s suitable for both geologic sequestration and enhanced oil recovery (EOR). Stewart and the team evaluated possible injection rates into vertical and horizontal injection wells and determined that rates as high as 8 million tons per year (Mt/y) could be obtained for a single vertical injection well, possibly higher for a horizontal well that isn’t limited by the thickness of the geologic formation.

The proximity of a sequestration site to EOR operations cannot be overlooked. And as surprising as it may sound to some, CO2 is not solely a combustion by-product, but a useful ingredient.

“Gas and oil companies have been injecting CO2 into wells for over 40 years,” explains Stewart. “CO2 is commercially viable.”

Where primary recovery operations generally recover upwards of 50 percent of the oil and gas, using CO2 for enhanced recovery can increase results to 80 percent.

“CO2 under supercritical conditions turns to liquid,” Stewart says. “It acts similar to trichloroethylene, or TCE, a nasty pollutant that dry cleaners used. Using supercritical CO2 is like dry cleaning the oil reserves; it strips the oil off the grains.”

While revenues from enhanced oil recovery do offset the cost of sequestration, the actual sequestration isn’t as effective. Quantity comparison?

And while permitting is required for using CO2 in EOR operations, it’s not an insurmountable hurdle. Permitting for CO2 sequestration; however, is currently in limbo. The US Environmental Protection Agency (EPA) hasn’t finalized underground injection permitting requirements, primarily over concern of groundwater contamination.

**Beyond physical**

When injection moves beyond physical into the chemical realm, this is when two more researchers come into play. Jeffrey Cunningham and Maya Trotz, both professors in the Civil & Environmental Engineering Department at USF, are involved with the chemical reactions that take place in the subsurface as CO2 is injected. For this the pair relied on TOUGHReact software to predict the geochemical response to a steady injection of CO2.

When CO2 is injected into a brine aquifer it lowers the pH, this in turn dissolves the minerals dolomite and calcite and precipitates gypsum. The concern is that these reactions could affect the porosity or permeability of the aquifer, thereby clogging the well and well area and limiting its efficacy. Modeling results indicate that the long term impact would be minimal on well performance.

In line with EPA’s concern is the release of contaminants. Previous research has shown that treated wastewater injected into aquifers caused the dissolution of arsenic from subsurface soils into groundwater.

“This is Maya’s specialty,” says Stewart. “She’s working with a consultant and a utility on the effect of injecting wastewater from a city and adding highly chlorinated material. Now we’re asking, ‘what if we pre-dissolve CO2 or co-inject CO2?’”

The question of pre-dissolving CO2 is posed as a matter of storage efficiency. When pre-dissolved, CO2 stays in solution it allows a greater volume of carbon to be sequestered, essentially packing more carbon into a unit of storage space.

**Where does this leave Florida?**

As utilities in Florida, and across the country, anticipate regulatory constraints on carbon, there’s no absolute on what scenario will play out. Regulations take the form of cap and trade or a carbon tax. Because utilities tend to be conservative in nature, planning 40 years into the future, this puts them in the position of having to prepare where no roadmap exists. This is more difficult in states that rely almost entirely on coal.

In Florida, electricity production relies heavily on natural gas which generates half the amount of CO2 per kW-hour of electricity when compared to coal. This positions Florida well with regards to avoiding financial impacts from carbon capping or taxing. However, even with a lower output, carbon will have to be addressed.

This may come about through sequestration projects, like Stewart’s, or industry changes, such as implementing more efficient combined-cycle combustion systems. Mostly likely it will be a combination of the two.