GULF COAST CARBON CENTER

Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

Synopsis

The Gulf Coast Carbon Center (GCCC) seeks to apply its technical and educational resources to implement geologic storage of anthropogenic carbon dioxide on an aggressive time scale. We have prepared a staged scope of work that includes a series of steps that are flexible with respect to increasing interest and funding for needed activities. In order to move rapidly toward implementation, we will combine three approaches:

(1) Focus on a geographic area where opportunities for early implementation are numerous and diverse and that have a high potential of being economically viable,
(2) Develop and distribute information needed to inform and engage all critical contributors to the system, and
(3) Develop and obtain additional funding for a strongly competitive next-stage field demonstration at an appropriate scale to demonstrate competence in measurement, monitoring, and verification (MMV) and project economic viability.

The geographic area selected for initial focus is the Gulf Coast of Texas, Louisiana, and Mississippi, where numerous refineries and chemical plants now produce concentrated CO_2 streams. These sources can be used to jump-start the sequestration process at a small scale before capture processes for combustion are mature. As capture options evolve in response to carbon-related greenhouse gas (GHG) issues, both refinery/industrial and electric-power generation facilities throughout the greater Gulf Coast region will be tapped to involve greater CO_2 volumes and serve the major coal-fired power plants of the region. The equivalent jump-start for geologic sinks will be hydrocarbon reservoirs in decline, which are numerous in the region and which provide economic offset for infrastructure costs, well-characterized subsurface environments, known trapping capacity, and a well-known regulatory setting. Very large volumes of brine-bearing formations in the subsurface are available to store large volumes of CO_2.

In the scope of this project, we will not research the options for terrestrial sequestration in detail. We will, however, continue to explore through literature review, how this option can be used in the region to complement and supplement geologic storage.

Through combined industry-academic funding we will:

- Identify and define a possible public framework in which sequestration activity can be developed, and the corresponding regulatory/ governmental guidelines within which it could evolve.
- Identify and prioritize major CO_2 sources in the region according to established project criteria (e.g. low cost, proximity to sink)
- Identify key sinks – both EOR and other geological sinks to which CO_2 supplies could be directed.
- Provide infrastructure outline for early phase and longer-term sequestration activities.
- Define and implement early phases of a public outreach program to all key constituent groups and various public entities.
- Set forth a phased implementation plan for a regional sequestration program with specific financial, environmental, and business objectives and parameters.

The goal is to bring interests, information, and insights together as efficiently and effectively as possible in order to set forth a pragmatic, viable plan through which actual geologic carbon storage/sequestration can be initiated. Ultimately, what is learned from this work will be exported to other EOR and CO_2 capture projects within the U.S. and abroad. Phase I will establish the framework for a Phase II field experiment.

Phase I: Carbon Management & Sequestration Development Program

Stage 1: A research participation program will pool seed money from the Jackson School of Geosciences and contributions from companies with financial, economic, and political interest in the challenges and opportunities created in a carbon-constrained environment [why carbon constrained?]. This fund will be used to develop the background needed to create one or more strong, competitive proposals for next-phase field demonstrations, as well as any needed supporting research. Early opportunities to propose additional field-based projects to obtain substantial matching funding from DOE are expected in 2004 and 2005. Therefore, an aggressive series of tasks to identify viable sites and secure participant and public interest is proposed. In Stage 1 we will:

- Identify one or more experimental sites, including a source and a sink with appropriate CO_2 stream and capacity;
- Select a strong collaborative research team with capabilities to conduct both enhanced hydrocarbon production activities and measurement, monitoring, and verification (MMV) activities, as well as to actively engage stakeholders through diverse types of outreach activities; and
- Identify funding for the field demonstrations from a combination of industries, State sources within the three states, Federal (DOE) sources, and international sources.

Stage 2. Additional assessment is needed to demonstrate the national and international significance of the project, including:

- Demonstration of a profit-driven plan under a plausible economic future scenario that develops a market for anthropogenic CO_2 in the region;
- Demonstration of the potential to scale-up in order to significantly reduce atmospheric emissions of CO_2, include advanced capture technologies, or use of clean coal generation; and
- Demonstration of risks to health and safety and to the environment being low and acceptable and the desired impact on the atmosphere being obtained through this process.

Stage 2 will include substantive liaison work to capture the large amount of research and applied experience being gained in carbon sequestration worldwide, in order to apply this experience to the Gulf Coast project, as well as to identify gaps in knowledge that the Gulf Coast project can fill. We expect to add additional members to our team for the expertise needed to complete these tasks, including other Jackson School researchers, members of the Center for Petroleum and Geosystems Engineering at The University of Texas at Austin, and U.S. and international research partners.

Stage 3. Stage 3 will include proposal preparation and follow-through before additional funding is received. Tight interconnection among tasks from capture to storage to long-term monitoring will be developed during this stage. This stage will also bridge the gap between Stage 1 site identification and getting the team in place and Stage 4 completion of all contract negotiations with funding sources and a large number of highly qualified international research teams needed to get into the field. Stage 3 will include early elements of site characterization, modeling, and risk assessment that are needed for an efficient move into the field.

Stage 4. Field pilot(s) will be conducted. On the basis of our current knowledge, we expect the pilot in the Gulf Coast will most likely be in an oil or possibly gas reservoir near a currently available source of high-concentration CO_2, such as a refinery or chemical plant. Significant governmental funding will be needed for this pilot to (1) reduce financial risk to the participants to acceptable levels and (2) fund a strong monitoring, modeling, and verification (MMV) effort for determining that the proposal Stage 2 assessment is correct. The field pilot will be conducted by a collaborative international team with the ability to conduct enhanced hydrocarbon production activities and monitoring and verification activities, and actively engage stakeholders through diverse types of outreach activities.

Stage 5: The intended near-term result of this field-demonstration program is to incubate one or more full-scale, for-profit applications of captured anthropogenic CO_2 and geologic storage for beneficial use.

Role of the Jackson School of Geosciences

The recent endowment from John A. and Katherine G. Jackson to establish the Jackson School of Geosciences at The University of Texas at Austin provides a unique opportunity for applying substantive geotechnical expertise to solving significant problems for the people of Texas and the Nation. The issue of carbon-dioxide storage to reduce accumulation in the atmosphere falls within the Jackson School goals because it (1) raises the prestige of the Jackson School on a national and international level, (2) requires cutting-edge research, and (3) applies this research to benefiting the people of Texas and of the planet. Jackson School funds require 50 percent matching funds from sources external to the school to assure that the research is truly significant.

Purpose and Goals

The purpose of the Gulf Coast Carbon Center (GCCC) is to develop a proactive response to changes in energy-related businesses that result from the need to reduce atmospheric releases of CO_2. Changes in combustion technology large enough to reduce the accumulation of CO_2 in the atmosphere will strongly impact the regional economy. The Gulf Coast of Texas, Louisiana, and Mississippi has strong links to hydrocarbon production, hydrocarbon refining, hydrocarbon-based manufacturing and consumption for manufacturing, and energy consumption by a large population. The region therefore has a need to develop options that take advantage of opportunities, as well as reduced dislocations created by changing combustion technologies. The public in the Gulf Coast area is at a high risk of negative impacts from GHG induced climate or environmental change.

A proactive response by regional industries has a high potential for influencing the evolution of markets for products and trading, electricity and hydrogen generation, governmental policy, and the regulatory environment both in the U.S. and worldwide. However, most businesses currently have inadequate information for developing a business plan in this complex system, which must link industries having varying degrees of expertise and different operational drivers. In order to develop a proactive response, the GCCC will lead the effort to collect available information, develop needed additional information, and distribute this information to businesses in the region. The need for pilot field demonstrations is widely recognized. The GCCC will therefore develop a well-designed intermediate-scale field pilot to follow up on the work that is now being done at a small scale with the Frio Brine Pilot. This intermediate-scale pilot will serve to increase local confidence in the concepts of enhanced oil recovery in the Gulf Coast, to evaluate the effectiveness of geologic storage in this setting, and to test and validate the processes for international application. Key technical products will include

- Testing the rapidly evolving modeling of CO_2 movement,
- Demonstrating effective monitoring strategies,
- Documenting the mechanical performance of shale seals and above-seal isolation zones,
- Testing the integrity of well construction in preventing return of CO_2 to the atmosphere,
- Testing the response of the far field geological agents, including fault stability and transmissivity, and
- Understanding better the effects of injection on usable underground water resources.

Why the Gulf Coast?

The Gulf Coast provides a world-class opportunity to study and develop business around carbon storage because of the unique combination of infrastructure, geology, knowledge, and government. Significantly as well are the opportunities for enhanced oil and gas recovery (EOR), an activity that could not only serve as a sink for GHG emissions, but can potentially extend State and local revenue streams beyond the currently projected time frame. While a carbon-constrained world is still an evolving public policy issue, should such an environment become reality, the region's fairly substantial economic links to process industries (chemical, petrochemical, refining,

etc.) could be jeopardized due to associated costs and uncertainty. Having a plan, developing a program, and providing the means through which to both minimize costs and lessen uncertainty not only are sound policy goals, but prudent economic objectives as well.

The following are regional attributes advantageous to such a development:

Infrastructure: The Gulf Coast has outstanding infrastructure in terms of low-cost CO_2 sources, transportation means, and industrial expertise. A diverse assemblage of stationary sources currently produces concentrated CO_2, such as hydrogen reformers and ethylene oxide and ammonia plants. In addition, half of the electric power generated in Texas is from coal-fired power plants. As advanced combustion technology becomes available for these facilities, they will need capacity for geologic storage of CO_2. The sources directly overlie large volumes of the subsurface that could store significant volumes of CO_2 in geological formations that have high injectivity and exhibit other desirable characteristics such as ability to mitigate upward fluid/ gas mobility. With a vast pipeline network across the region, issues pertaining to rights-of-way, safety, and related key concerns have already been addressed. Extending this experience to creating a CO_2 pipeline infrastructure within or alongside that currently existing will be easier than pioneering the pipeline system. In addition, the presence of active drilling and geophysical and geochemical industries will allow MMV to proceed at a low cost relative to that of other U.S. locations.

Geology: The Gulf Coast has a superabundance of attractive storage sites. Numerous depleted oil and gas reservoirs provide well-characterized subsurface volumes of known trapping capacity and the potential for enhanced hydrocarbon recovery to offset infrastructure costs. These are associated with saline aquifers having similarly well-understood and well-characterized porosity, permeability, and structure. Finally, many of the saline aquifers are in or near structural closures. No other land-based region in the U.S. has such large storage potential or such well-understood geology.

Knowledge: The geological, geophysical, and geochemical base of expertise in the Gulf Coast region is the pride of the energy industry and the many universities and institutions in the region. The world's most concentrated knowledge about CO_2 EOR in the Permian Basin lies within the state and can be transferred to the Gulf Coast because operators and investors already have experience with EOR. This knowledge and expertise will be critical to the eventual development of a viable CO_2 storage/ sequestration industry and will promulgate technology developments in the energy area.

Government: The regulatory framework for injection either for enhanced hydrocarbon recovery or for subsurface disposal is well known, and the population of the region has experience with subsurface and industrial processes. Similarly, government agencies along the Gulf are familiar with the needs of both the industry and the local population and can build both a regulatory framework and market mechanisms that will serve the interests of both parties.

This combination of assets and common interests facilitates a relatively straightforward implementation of CO_2 storage, as well as great flexibility in how the process is implemented. Initially small volumes of currently available concentrated CO_2 can be used in demonstration-scale, enhanced-hydrocarbon-recovery projects. As the market evolves, small sources could then be aggregated for larger hydrocarbon recovery projects, and newly concentrated sources created by maturation of capture technologies will be added into the system. Enhanced oil or, possibly, gas recovery in fields in decline will segue into storage in large-volume brine aquifers, off-structure or below the producing reservoir.

The field pilot currently underway—the Frio Brine Pilot, that will be completed this fiscal year—will provide an initial test of the capacity of seals, fluid-flow processes, and well completions. The simplified (brine rock) environment was selected to test the capability of monitoring CO_2 migration using multiple tools and matching the observed performance with numerical models. It was designed to produce results over a brief timeframe with

small volumes of injected CO_2. The next scale of test will complement the Frio Brine Pilot by involving a more complex system, containing oil and/or gas, as well as brine and rock, and be sited near a source of CO_2. In this way, large volumes can be injected over time to better test the capacity of the system (residual trapping, solubility trapping, wells, faults, seals) to retard release of CO_2 to the atmosphere. Further testing at the Frio Brine Pilot site is also possible if questions arise that are best resolved in that setting.

CO_2-enhanced oil production has been undertaken before in the region and has been marginally economic. We will further explore the lessons learned during these experiments and assess what incentive is needed to create favorable economics for the region. Through regional carbon-sequestration partnerships recently identified by DOE, the experience gained in this project will be exported to other regions in the U.S. that have refinery and chemical plant CO_2, such as Los Angeles or the northern Rockies.

Coordination with Other Efforts Under Way

We intend to work proactively to maintain and further develop strong cooperative relationships with other U.S. and international researchers in the field of sequestration and DOE and increase the interest of State entities. We will seek to coordinate our efforts with the newly formed regional sequestration partnerships and complement their efforts to expand the potential for greenhouse-gas reduction in this special-case area. We will maintain a strong information exchange for the mutual benefit of international workers in this arena and seek means to transfer this technology to global partners.