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**Ian J. Duncan  
William A. Ambrose  
Mark H. Holtz  
Susan D. Hovorka  
Vanessa Núñez-López  
Joseph Essandoh-Yeddu  
Jean-Philippe Nicot  
Rebecca C. Smyth  
Srivatsan Lakshminarasimhan**



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# THE GULF COAST CARBON CENTER: DEVELOPING A CARBON SEQUESTRATION INDUSTRY IN THE GULF COAST REGION

Ian J. Duncan<sup>1</sup>, William A. Ambrose<sup>1</sup>, Mark H. Holtz<sup>1</sup>, Susan D. Hovorka<sup>1</sup>,  
Vanessa Núñez López<sup>1</sup>, Joesph Esandoh-Yeddu<sup>2</sup>, Jean-Phillippe Nicot<sup>1</sup>,  
Rebecca C. Smyth<sup>1</sup>, Srivatsan Lakshminarasimhan<sup>1</sup>

<sup>1</sup>Gulf Coast Carbon Center, Bureau of Economic Geology, Jackson School  
of Geosciences, The University of Texas at Austin, Box X Austin Texas  
78713-8924

<sup>2</sup>Ghana Energy Commission, Ghana

## Abstract

The vision of the Gulf Coast Carbon Center is to seek to impact global levels of GHG in the atmosphere by doing science and engineering studies that will support reduction of CO<sub>2</sub> emissions and enable the development of an economically viable, multifaceted, CO<sub>2</sub> sequestration industry in the Gulf Coast. This industrial-academic consortium is investigating issues related to assessing the pathways that would make capture and pipeline transportation economically feasible and environmentally effective within a specific regional context. Key issues considered are capture in the context of the current market, pipeline infrastructure, the role of enhanced oil recovery, and permanence in a basin with many wells.

**Keywords:** Gulf Coast, Texas, CO<sub>2</sub>-EOR, economics

## Introduction

A significant portion of the global total of carbon emissions, approximately one Gigaton comes from the Gulf Coast region of Texas, Louisiana, and Mississippi [1]. This represents 16 percent of the annual USA CO<sub>2</sub> emissions from fossil fuels. The Gulf Coast region also provides an opportunity for addressing the problem. Geologic sequestration enables fossil fuel to be decarbonized by capturing CO<sub>2</sub> from the combustion products and injecting the gas compressed gas into a super-critical fluid into the subsurface saline brine aquifer for long-term storage. The Gulf Coast overlies a thick clastic sequence comprised of a variety of porous and permeable sandstone aquifers, separated by thick shale aquitards, typical of passive continental margins [2]. This sedimentary wedge provides an amount of potential storage that is best described as vast and realistically aggregate to hundreds of Gigatons of storage. Regional flooding surfaces have deposited thick and extensive layers of low permeability shales that separate the sandstone injection zones and will assure storage for thousands of years. The region also provides a wide variety sequestration options such as: coal/lignite formations (and enhanced coal bed methane projects); depleted gas reservoirs (and enhanced gas recovery projects); depleted oil reservoirs (and enhanced oil recovery projects). Experience from this region can potentially be exported to similar settings globally.

The Bureau of Economic Geology (BEG), part of the Jackson School of Geosciences has formed the Gulf Coast Carbon Center (GCCC) to carry out applied research in developing strategies and protocols for long term geologic storage of carbon the in deep subsurface of the Gulf Coast. The GCCC is a partnership between the BEG and corporations including BP, Chevron, Entergy, Kinder Morgan, Marathon, NRG Energy, Praxair, and Schlumberger. The vision of the GCCC is to seek “to impact global levels of GHG in the atmosphere by doing science and engineering studies that will support reduction of CO<sub>2</sub> and methane emissions and enable the development of an economically viable, multifaceted, CO<sub>2</sub> sequestration industry in the Gulf Coast”.

## **Building Scenarios For Large Scale Geologic Storage in the Gulf Coast, USA**

GCCC research staff, in conference with corporate partners, have selected a number of research issues to consider within a specific regional context. Issues under investigation are capture, economic pathways forward, the role of CO<sub>2</sub>-enhanced oil recovery (EOR) in large volume storage, and mechanisms to assure that storage is secure.

We inventoried 0.4 billion tons of CO<sub>2</sub> produced annually from 316 stationary sources in the region. Capture of CO<sub>2</sub> from these sources could supply a 680-mile pipeline infrastructure linking the Gulf Coast region in a network that can be imagined extending from Alabama into Mexico. Initially the first segments of this regional pipeline network will link sources of high concentration CO<sub>2</sub> emissions, such as hydrogen plants and gasification plants to EOR sites. Large scale storage of CO<sub>2</sub> emitted from current sources would require decarbonizing fossil fuels by retrofitting current power plants and factories with CO<sub>2</sub> scrubbers. This is capital intensive and is typically accompanied by a high energy penalty. Gasification of coal, lignite, petcoke and/or biomass provide a way of extracting energy from coal that has the advantage of producing CO<sub>2</sub> in much higher concentrations than in pulverized coal power plants. Gasification of coal produces syngas composed of hydrogen and CO<sub>2</sub>, with CO<sub>2</sub> in sufficiently high concentrations that traditional separation technologies are cost effective. Coal gasification provides an interesting nexus between the CO<sub>2</sub> and hydrogen value chains. The Gulf Coast is already the largest market in the USA for hydrogen. Plants that gasify coal, lignite, petroleum coke and/or biomass (either as integrated gasification and combined cycle turbine power [IGCC] power plants or as stand alone producers of hydrogen gas for the refinery or chemical plant market) will likely be built in the Gulf Coast over the next few years in response to several economic drivers:

- (1) rising prices for natural gas will provide incentives to refuel existing gas turbine plants,
- (2) increasing demand for hydrogen for refining petroleum (projected as 10% or more over the next ten years), together with the increasing cost of steam reforming natural gas to produce hydrogen will make gasification of cheap fuels such as petcoke and lignite more attractive,
- (3) increasing cost of adding scrubbers to pulverized coal power plants to meet more rigorous environmental standards; leading to construction of IGCC plants

In addition to CO<sub>2</sub> capture, a regional system of a pipeline backbone and trunk lines, together with distributed compression, is necessary to develop a CO<sub>2</sub> sequestration industry in the Gulf Coast. The GCCC is currently conducting economic modeling of possible a future CO<sub>2</sub> value chain in the Gulf coast by:

- 1) Evaluating the hypothesis that regional pipeline backbone complexes linking many sources and sinks are both more cost effective than linking source-sink pairs. Such a backbone can also help stabilize variations in capture and injection rates from individual sites.
- 2) Testing the assertion that the capital costs for adding capture to existing plants and building compressors and pipeline complexes are prohibitively and require substantial carbon penalties (or credits) or other incentives. This is based on models of cash flow for EGR and/or EOR being utilized as the sink for CO<sub>2</sub>.
- 3) Estimating a future fair market value for CO<sub>2</sub> in the Gulf Coast by evaluating cash flow from potential CO<sub>2</sub> EGR and EOR projects and estimating possible penalties for levels of contaminants in CO<sub>2</sub> being sold into a future pipeline network.

### **CO<sub>2</sub>: A Potentially Valuable By-Product**

The Permian Basin of Texas and New Mexico, USA, is currently the largest commercial market for CO<sub>2</sub> in the world. The average price of CO<sub>2</sub> being sold from the pipeline network for EOR in the Permian Basin is not public information, however prices are probably in the range of \$14 to 20 per ton. The total market for CO<sub>2</sub> in the Permian Basin is estimated to have a value of about \$450 Million annually.

Texas corporations and technical workers have a unique experience base and outstanding safety record, in pipeline transport and subsurface injection of CO<sub>2</sub>. Since the early 1970s, CO<sub>2</sub> has been injected into

many Permian Basin oil reservoirs to enhance production. Injected CO<sub>2</sub> is dominantly produced from natural accumulations and pipelined to the Permian Basin. In addition, on the order of ~10% is now derived from other sources such as gas processing plants where the CO<sub>2</sub> would otherwise have been released to the atmosphere. Currently roughly 30 MMt CO<sub>2</sub> are injected annually in the Permian Basin in operations that are closed-cycle. In other words, CO<sub>2</sub> that is produced from the reservoirs in association with the recovered oil is re-injected into the reservoir for additional recovery. As a result, a very large amount (on the order of 10<sup>8</sup> metric tons or MMt) of CO<sub>2</sub> has accumulated in these reservoirs for storage.

Many individual operations in the Permian Basin are at the scale of CO<sub>2</sub> production associated with coal burning power plants. As an example, the SACROC unit near Snyder, Texas, USA currently injects ~13.5 MMt CO<sub>2</sub>/yr and withdraws/recycles ~7 MMt CO<sub>2</sub>/yr, for a net storage of ~6.5 MMt CO<sub>2</sub>/yr [3]. For comparison, a 500 MW pulverized coal power plant produces roughly 3–4 MMt CO<sub>2</sub>/yr. Hence, the site infrastructure at SACROC—which includes ~1850 wells, compression facilities, and a CO<sub>2</sub> distribution/injection network—is comparable to the scale of facilities that would be required for Gigaton quantities of power plant CO<sub>2</sub>. CO<sub>2</sub>-flooding for enhanced oil recovery (EOR) has been active at SACROC in Scurry County since 1972.

### Expanding CO<sub>2</sub>-Based Enhanced Oil Recovery to the Gulf Coast – Synergy with Geologic Storage

The Gulf Coast has a large potential for CO<sub>2</sub> enhanced oil recovery (EOR) outside of the traditional area of CO<sub>2</sub> EOR in the Permian Basin. Using the miscibility screening criteria of Holtz [4] we inventoried 767 oil reservoirs where miscible CO<sub>2</sub> EOR could be applied for an additional 4.7 billion barrels of oil recovery (figure 1). By way of comparison, annual oil production in USA is currently 3.2 billion barrels. This incremental production target is attractive because of value in terms of wellhead value, tax revenue, and economic activity. This EOR activity would lead to the use of large amounts of CO<sub>2</sub>, however, it is small in the context of the projected 75 Gigatons of CO<sub>2</sub> emissions for the Gulf Coast over the next 50 years. Industries that early in the processes of emissions reduction develop a market for CO<sub>2</sub> will benefit from these economic activities.

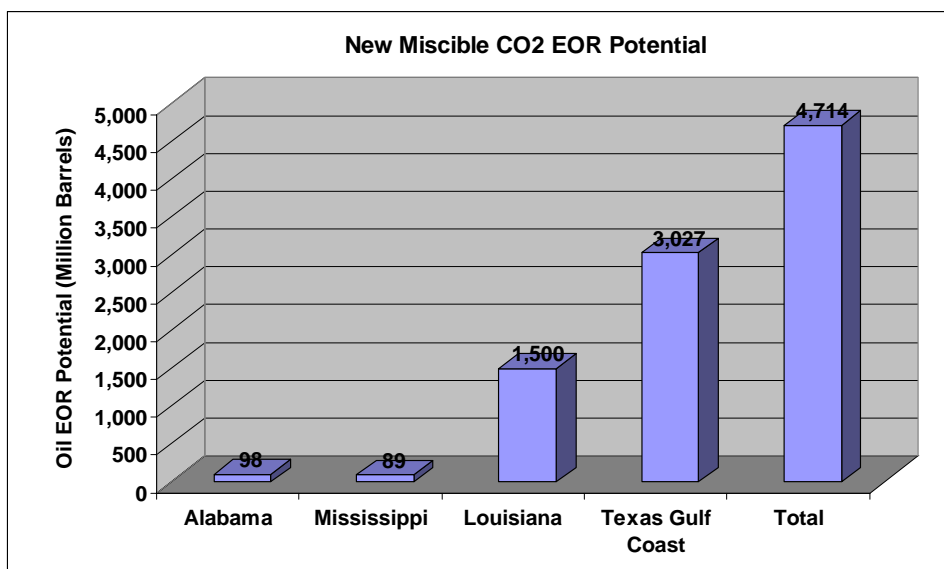


Figure 1. Assessment of volumes of oil that could be recovered by miscible EOR outside of the traditional EOR regions in the Permian Basin.

EOR results in storage of CO<sub>2</sub> dissolved in residual oil, dissolved in brine, and trapped as an immobile supercritical phase. Experience in Permian basin EOR projects is that 1/3 to 1/2 of the injected CO<sub>2</sub> is retained in the reservoir. However, the volume retained as a by-product of EOR is small relative to total point source emissions. The large synergy between EOR and reducing carbon emissions is that EOR would enable the construction of an infrastructure linking sources to reservoirs. Very large volumes of

brine filled porosity can then be accessed beneath oil production, a concept that we describe as stacked storage. Existence of an infrastructure would reduce the cost of storage of Gulf Coast power plant, refinery, and chemical plant emissions for the next 50 years or more.

It has long been known that mechanically engineered systems are the weak point of injection operations, and US Environmental Protection Agency underground injection control regulations require investment in remediation of old wells and construction and maintenance of new wells. This issue has recently emerged in the forefront of concerns for geologic storage in areas with abundant wells [5]. Injecting CO<sub>2</sub> beneath the major zones of oil production in a stacked storage concept decreases the number of wells, especially older wells, that are areas of concern for short and long term leakage. In Tertiary sediments of the Gulf Coast, gains in CO<sub>2</sub> density offset loss of porosity with depth down to 3000 m or more.

Intersection the rising need for effective storage for CO<sub>2</sub> with the traditional knowledge about the role of reservoir architecture in the Gulf Coast region provides interesting new research opportunities to maximize storage. A study of reservoir architecture provide information about sand body geometry and continuity that allow selection of injection environments that optimise for required storage characteristics, for example high injection rates or minimum spread. Input of sandbody distributions and structural framework into numerical simulators provides additional information for locating good quality storage.

## **Conclusions**

The Gulf Coast of the USA is a region of high CO<sub>2</sub> emissions that overlie thick, extensive, and well known subsurface geologic formations. Path forward toward developing an economically viable system for capture and storage include: (1) development of a climate favoring construction of gasifiers of coal, lignite, petcoke and/or biomass as sources, (2) construction of a pipeline backbone to transport CO<sub>2</sub> regionally, (3) a market for CO<sub>2</sub> for EOR in areas beyond the traditional area of use in the Permian Basin, and (4) development of stacked storage, using deeper brine-bearing formations beneath hydrocarbon reservoirs.

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