



CO₂ Utilization and Storage from CO₂ Enhanced Oil Recovery for the U.S. DOE/NETL Carbon Sequestration Atlas

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**Advanced Resources
International, Inc.**

Introduction

The storage of CO₂ with Enhanced Oil Recovery (CO₂-EOR), a key aspect of CCUS (Carbon Capture, Utilization and Storage), is receiving increasing interest.

A number of the current CO₂ capture projects are using CO₂-EOR for CO₂ storage and for revenues to help defray the costs of capturing CO₂.

- Southern Company's Kemper County IGCC Plant
- Summit Power's Texas Clean Energy Project
- Others (e.g., North Dakota Coal Gasification, Boundary Dam Integrated CCUS Project, etc.)

Advanced Power Plants Plan to Use EOR for CO₂ Storage

Southern Company's Kemper County IGCC Plant

- 582 MW fueled by Mississippi Lignite
- Will Capture 65% of CO₂
- Negotiating agreement to sell 1.1 to 1.5 million tons of CO₂ per year for EOR (170-225 MMcfd)
- Project expected to cost \$2.4 B and be operational by 2014.



*Source: Mississippi Power, Denbury Resources

Summit's Texas Clean Energy IGCC Project

- 400 MW IGCC with 90% capture
- Located near Odessa in Permian Basin
- Sell 2.5 million tons of CO₂ per year to EOR market
- Expected cost \$1.75 B; \$350 MM award under CCPI Round 3.



Source: Siemens Energy

Improving Information in the DOE/NETL Atlas

The U.S. DOE/NETL 2012 Carbon Sequestration Atlas of the United States and Canada – Fourth Edition (“Atlas IV”), prepared by NETL and the various Regional Carbon Sequestration Partnerships, provides information on CO₂ storage capacity for oil and gas reservoirs.

- Two methods are currently used to estimate the CO₂ storage volume: (1) a volumetrics-based CO₂ storage estimate and (2) a production-based CO₂ storage estimate. The method selected by each RCSP is based on available data.
- The CO₂ storage volumes in the “Atlas” represent technical storage capacity and not the economically viable market demand for CO₂ by the EOR industry.

Key Study Topics

The purpose of this study is to work with the Regional Partnerships to address the following topics:

1. How large of a CO₂ utilization and storage market does CO₂ enhanced oil recovery (CO₂-EOR) offer in each Partnership region?
2. How would the size of the CO₂ utilization and storage market offered by CO₂-EOR match the available sources of CO₂ in the Partnership regions?
3. How would the demand for CO₂ utilization and storage by the CO₂-EOR market vary as a function of oil prices?
4. How would the CO₂-EOR based utilization and storage of CO₂ compare with the volumetrics or production-based estimates of CO₂ storage currently prepared by each Partnership?

Work Plan and Scope

The work is being performed as part of a joint effort by ARI, MGSC, SSEB and the U.S. DOE's RCSPs.

Phase I of the study is developing and testing an updated CO₂ utilization and storage methodology for CO₂-EOR. This work involves project management by SSEB and joint technical work between ARI and the Midwest Geological Sequestration Consortium (MGSC).

Phase II of the study will apply the CO₂ utilization and storage methodology developed in Phase I to assess CO₂ storage from CO₂-EOR with participation of each of the RCSPs.

Phase I Work Plan

Subtask 1. Develop Methodology for Estimating CO₂ Utilization and Storage Offered by CO₂ Enhanced Oil Recovery with Midwest Geological Sequestration Consortium (MGSC).

- Geologic and Reservoir Data
- Screening Criteria Oil Reservoirs Technically Viable for CO₂-EOR
- Cost and Economic Data and Model

Subtask 2. Work on CO₂ Storage and Oil Recovery Methodology with MGSC.

Subtask 3. Calculate Economically Viable Oil Recovery and CO₂ Storage Capacity for the Illinois Basin.

Subtask 4. Establish Working Group Involving Technical Level Participants from the Regional Carbon Sequestration Partnerships.

Progress to Date

Atlas IV. DOE's RCSPs have estimated 226 billion metric tons of CO₂ storage capacity.

CO ₂ Storage Oil and Gas Reservoirs	
RCSP	Billion Metric Tons
BSCSP	1
MGSC	1
MRCSP	14
PCOR	25
SECARB	32
SWP	149
WESTCARB	4
Total	226

Previous MGSC Study Results

State	CO ₂ Storage Resource (million metric tons)	Estimated EOR* (million barrels)
Illinois	106 to 358	632 to 979
Indiana	20 to 47	124 to 162
Kentucky	14 to 35	104 to 138
Total	140 million to 440 million metric tons	860 million to 1.3 billion barrels

*EOR volume was estimated using oil recovery factors for specific geologic units and miscibility type, applied to the original oil in-place per oil field.

New MGSC Study. Develop dimensionless CO₂-EOR performance curves for Illinois Basin geologic formations, calibrate curves via rigorous geologic and reservoir models, and incorporate results into an economic model.

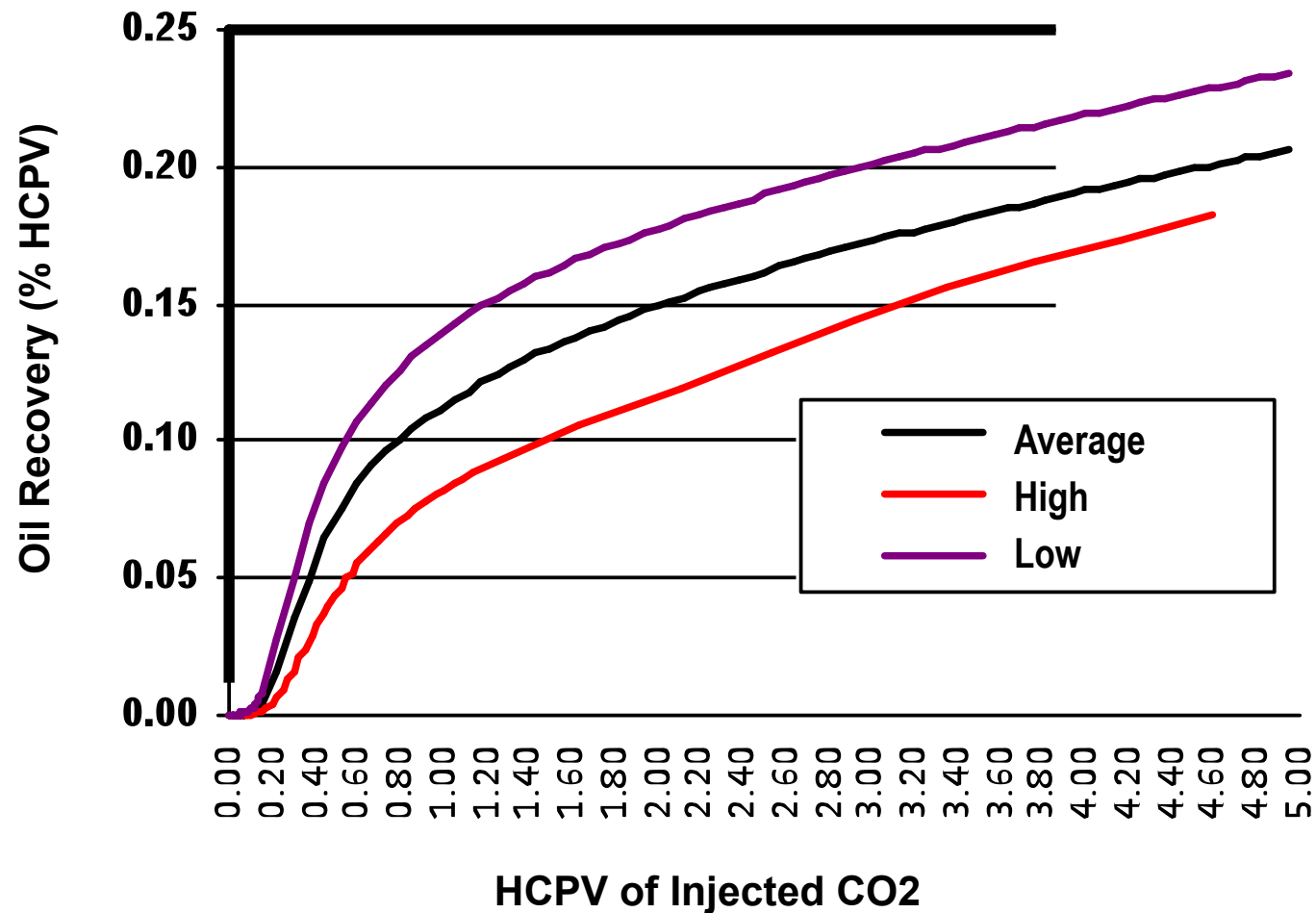
Master Input Data Sheet: Reservoir Specific Performance Curves

The Master Input Data Sheet enables the model user to:

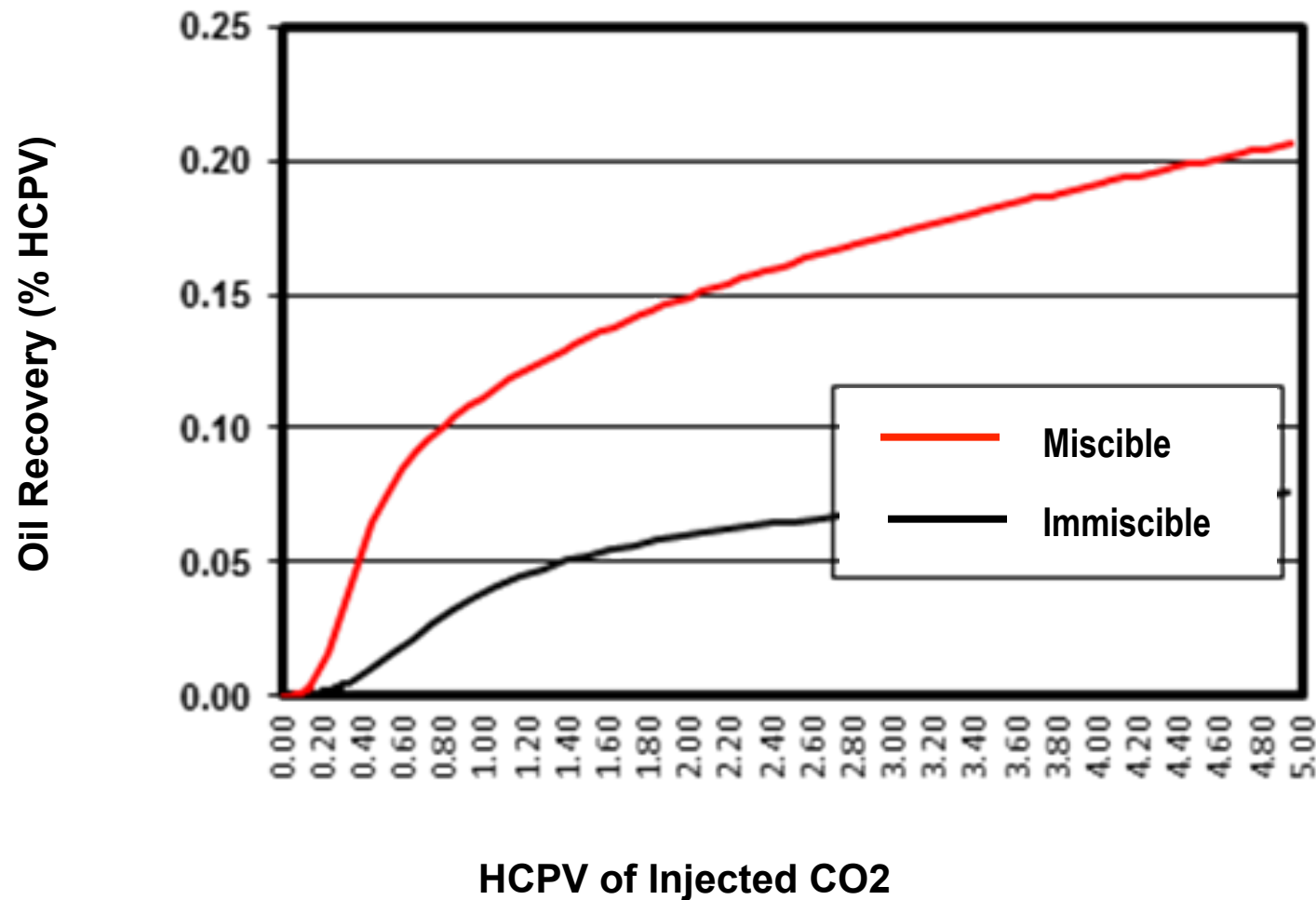
- Select a representative performance (“type”) curve.
- Enter appropriate fluid injection rates.
- Generate oil recovery and CO2 utilization projections
 - Graphics
 - Tables

Performance Curve Selection Unique Scenario ID: <input type="text"/> CO2 Inj Startup: 01/01/2014 Heterogeneity: Average <input type="button" value="v"/> Miscibility Type: Miscible <input type="button" value="v"/> Injection Type: WAG 20% HCPV <input type="button" value="v"/> Inj Pattern (acre): 20 <input type="button" value="v"/>		CO2 Injection Rate Setup Select CO2 Inj Rate Method <div> <input type="button" value="Pre-CO2 WF Based CO2 Rate"/> <input type="button" value="CO2 Rate Directly"/> </div> No. CO2 Inj Wells: 30 WF qw (stb/day per well): 150 qg (rb/day)/qw (stb/day): 1.2 Recommended qg/qw: 1.0 - 1.5	
Reservoir Volume Factors Bo (rb/stb): 1.054 Bw (rb/stb): 1.005 Bgco2 (rb/Mscf): 0.4		Continuous Water Production WOR WF qw (stb/day): 150 WF qo (stb/day): 1	
Reservoir Volume (Patterns, Field) Select and enter OOIP or HCPV <div> <input type="button" value="OOIP (Mstb)"/> Volume: 50000.0 <input type="button" value="HCPV (Mrb)"/> </div> HCPV Limit (max 5 HCPV): 5		Preview or Save PC Data Option <div> <input type="button" value="1A. Graph PC Projections"/> <input type="button" value="1B. Tabulate PC Projections"/> </div> <input type="button" value="2. Generate Projections"/>	

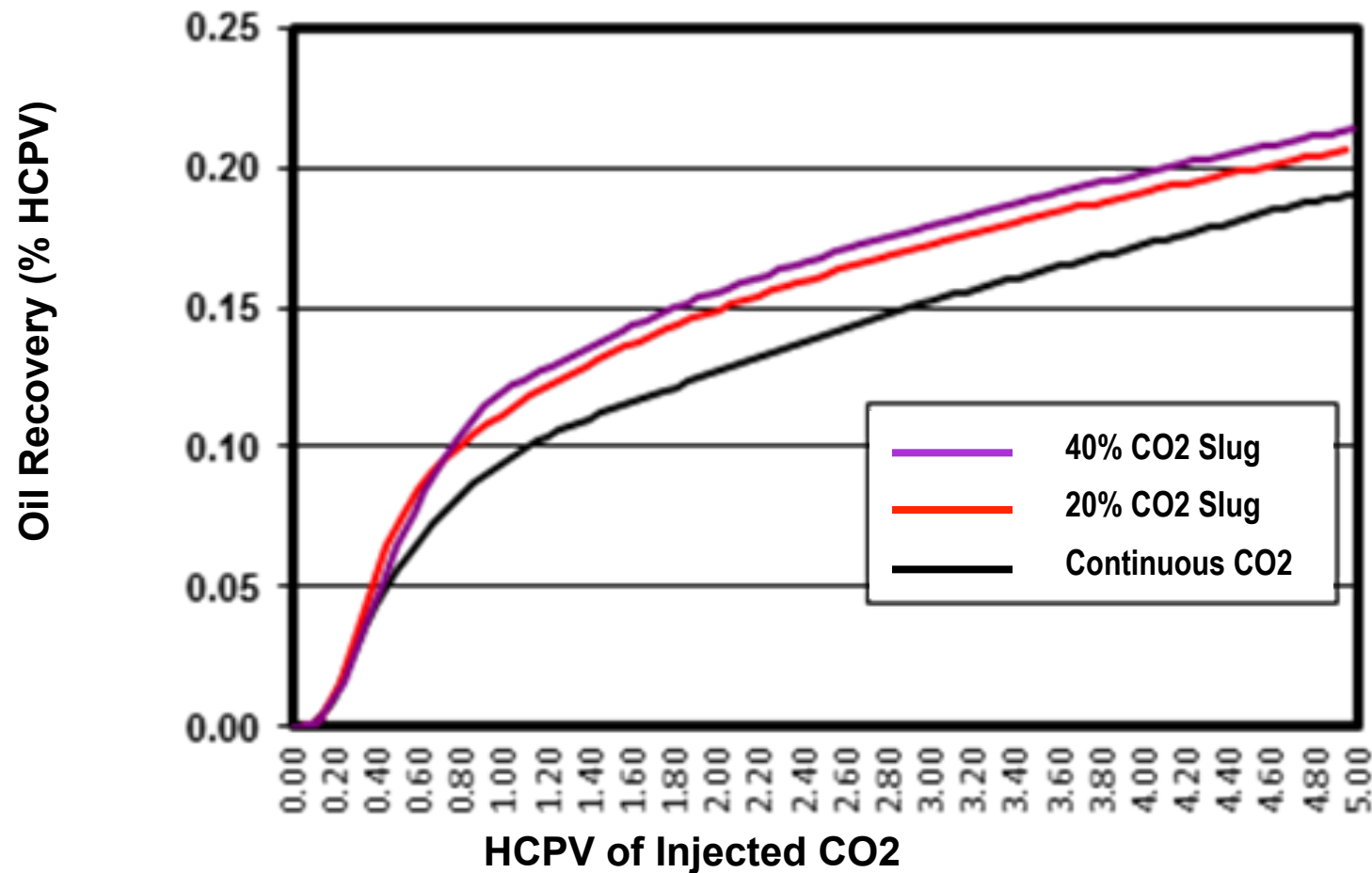
Performance (“Type”) Curves: Oil Recovery vs. CO₂ Injection (Three Grades of Reservoir Heterogeneity)



Performance (“Type”) Curves: Oil Recovery vs. CO₂ Injection (Two Types of CO₂-EOR)



Performance (“Type”) Curves: Oil Recovery vs. CO₂ Injection (Three Types of CO₂-EOR Process)



Concluding Thoughts

The work by the MGSC, particularly by Mr. Scott Frailey, has established an improved approach for calculating CO₂ storage and oil recovery and Trimeric has provided capital and operating costs for CO₂-EOR.

Advanced Resources, drawing on this valuable work, is in the process of integrating the MGSC developed performance (“type”) curves with the economic model.

In Phase II, we will work with each of the Regional Partnerships to test and incorporate this methodology for strengthening this information on CO₂ utilization and storage in each Partnership Region.



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