Industrial CCUS Regional Engagement
Enabling the CCUS Business Model

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The Industrial CCUS Regional Engagement is a set of regionally public-private partnerships that establish regional business CCUS models and engagements that convey the current profitability of the industrial CCUS sector where CO2 capture is less than $30/ton.

This effort will establish initial CO2 markets within each region and set the conditions for rapid and wide spread expansion of the market when the profitability of CO2 capture from power plants is realized.
Integrated Carbon and Energy Management

**Advanced Power Systems**
- Chemical Looping
- Pressurized Oxy
- Supercritical CO₂ Cycles
- REMS
- SOFC
- MHD

**Existing Power Plants**
- Pulverized Coal
- Gasification
- NG Combined Cycle
- Single cycle NG turbine

**Industrial Facilities**
- Chemicals/Fertilizer
- Cement
- Steel
- Plastics

**Gas Separations (CO₂/H₂/N₂)**
- Absorption
- Adsorption
- Membranes
- Cryogenic
- Novel Systems

**CO₂ Use and Reuse**
- Mineralization
- Algae
- Catalysts
- Novel Concepts

**Products to Market**
- Chemicals
- Pharmaceuticals
- Plastics
- Cement
- Carbon Fiber
- Animal Feed

**Natural Resources**
- Fossil Fuels
- Soils
- Biomass

**Renewable Energy**
- Bioenergy
- PV
- Wind
- Geothermal
- CSP
- Hydro

**GRID**
- Firm Power

**Low C Fuels**
- Electricity
- Heat
- CO₂/H₂/N₂ Gases
- Fossil Fuel
- Biomass
- H₂O/Sun/Wind/Air
- Products

**Advanced Vehicles**
- EV/Hybrid
- SuperTruck

**Firm Power**
- Coal
- Gas
- Nuclear
- Hydro
- Wind
- Solar
- Advanced Systems

**Products**
- CO₂ Use and Reuse
- Mineralization
- Algae
- Catalysts
- Novel Concepts

**EOR/Storage**
- Saline Storage
- EOR/Storage
CO$_2$ Supply Curve: Now and 2030

Capture from U.S. Existing Sources

30 million tonnes per year at high purity industrial point sources; now

If RDD&D is successful, can capture approximately 400 million metric tons of CO2 per year at roughly $30 per metric ton of CO2 and 1000 million metric tons at under $35 by 2030
CCS is Critical for Industrial Sources

• Globally, industry accounts for 40% of energy-related CO$_2$ emissions -- mostly in developing countries
• Many industrial facilities are large point sources
• In some plants, CO$_2$ is already being captured in order to produce the desired product (e.g., H$_2$/Ammonia), and additional capture cost is minimal
• CO$_2$ concentration in treated stream may be high or nearly pure
• Often located near potential storage sites
Regional Industrial CCS Engagement

**Vision:**
- Rapidly implement “technology ready” industrial Carbon Capture and Storage (CCS) projects by using convening abilities and current information distribution on CCS that conveys the high level of momentum and reduced risk needed to start an industrial CCS business case.

**Strategy:**
- Establish a business case for CCS regionally
- Establish public-private partnership working groups
  - Focus on including individuals with regional experience in CCS
- Facilitate informational outreach on CCS lessons learned, policy, and project financing.
Regional Engagement Areas and Points of Focus FY16 & FY17
### The Regions

<table>
<thead>
<tr>
<th>EOR Centric</th>
<th>Non-EOR Centric</th>
<th>Transformational</th>
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<tbody>
<tr>
<td><strong>Gulf</strong></td>
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<tr>
<td>- Four focus points</td>
<td>- Aligned with ADM Demonstration</td>
<td>- Longer term effort</td>
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<tr>
<td>- Workshop 1-3 Nov</td>
<td>- Tied to tax credits and Class 6 permitting</td>
<td>- Find rapidly fielded disruptive technologies (CO2 in unconventional?)</td>
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<td>- Pilot area</td>
<td>- New industry opportunity?</td>
<td>- Integrated into a small CO2 value chain (CO2 usage with REE?)</td>
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<td>- Refit existing site(s)</td>
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<td>- Pipeline hub opportunity?</td>
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<tr>
<th>Great Northern Plains</th>
<th>San Francisco Bay Area</th>
<th>Appalachia Region</th>
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<tr>
<td>- Aligned with Methanol production</td>
<td>- Refinery opportunity?</td>
<td>- Longer term effort</td>
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<tr>
<td>- Tribal engagement</td>
<td>- Tied to California clean fuel law</td>
<td>- Find rapidly fielded disruptive technologies (CO2 in unconventional?)</td>
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<tr>
<td>- Coal to Chemical opportunity?</td>
<td>- Small scale utilization opportunity?</td>
<td>- Integrated into a small CO2 value chain (CO2 usage with REE?)</td>
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Within Each Region:
1. Identify and establish a public-private stakeholder and advocacy “industrial CCS” working group.

2. Convene the working group to exchange information on the region group.

3. Lead the development of technical information in support of policy and financing recommendations that can be passed to decision makers.

4. Organize a regional “roundtable” and other outreach activities aimed at reaching numerous domestic and international stakeholders, thereby amplifying the working group’s results and enabling as broad an audience as possible.
The Gulf Coast, the First Region:

The Stakeholder/Advocates:
- Hood, Baumann, & Associates
- Center for Energy Studies, Louisiana State University (LSU)
- Louisiana Chemical Association
- Koch Companies Public Sector
- Southern States Energy Board
- Gulf Coast Carbon Center, The University of Texas
- Technology Assessment Division and State energy Office, Louisiana Department of Natural Resources
- North American Carbon Capture & Storage Association
- Shell Oil Company
- Regions Bank
- Mississippi Energy Institute (MEI)
- National Strategic Planning & Analysis Research Center (NSPARC), Mississippi State University
- AFL-CIO
- Clean Air Task Force
- Occidental Petroleum
**Not your typical “Roundtable”**

Convinces business leaders that current technologies have enough momentum and risk reduction to set up business success

Meeting focused on human business decision making; not just presentations; the difference between presenting data and convincing to act on a business case

Roundtable planning consists of:

- Event Design
- Information presentation context/ messaging design
- Supporting model development (e.g. Financial modeling)
- Existing data/study operationalization to support business models
- Event Execution (who shepherds whom?)
Backups
The Possible Market

Next Generation CO\(_2\) Oil Recovery
Source: Denbury modified from Advanced Resources International

CO\(_2\) Requirements

20 Billion Tons of CO\(_2\) Yields 67 Billion Barrels of Additional Oil

CO\(_2\) Oil Recovery

Context - Total Proven US Oil Reserves @ 2010 = 30.9 Billion BBL
BP Annual Statistical Review - 2011
The Possible Suppliers

Industrial CO₂ Capture Opportunities in Louisiana
Industrial CO₂ Utilization Opportunities in Louisiana

The Possible Buyers

Summary

<table>
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<tr>
<th>Category</th>
<th>Value</th>
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<tbody>
<tr>
<td>Proved</td>
<td>179</td>
</tr>
<tr>
<td>Potential</td>
<td>365</td>
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<tr>
<td>Produced-to-Date</td>
<td>99</td>
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<tr>
<td>Total MMBOEs</td>
<td>643</td>
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Houston Area

- Hastings: 60 - 80 MMBbls
- Webster: 60 - 75 MMBbls
- Thompson: 30 - 60 MMBbls
  - Total: 150 - 215 MMBbls

Conroe

- 130 MMBbls

Mature Area

- 170 MMBbls

Delhi

- 45 MMBbls

Tinsley

- 46 MMBbls

Heidelberg

- 44 MMBbls

Oyster Bayou

- 20 - 30 MMBbls

~90 Miles
Cost: ~$220MM

Green Pipeline
~325 Miles
The Prices

Preliminary Financial Modeling Results

**CO₂ Capture and Transportation Costs $/Metric Ton**

- Ammonia 1.0 DSCR
- Ammonia 1.25 DSCR
- Ammonia 2.0 DSCR
- Ethylene Oxide 1.0 DSCR
- Ethylene Oxide 1.25 DSCR
- Ethylene Oxide 2.0 DSCR
- Hydrogen 1.0 DSCR
- Hydrogen 1.25 DSCR
- Hydrogen 2.0 DSCR

- Capture
- Transportation

*Cost estimates based on capture of 1,000,000 Metric Tons/year and 100 mile pipeline*
Oil Prices

Over Time, Oil Projections Have Varied

World Oil Prices $/bbl*

*Source: EIA Annual Energy Outlook