United States Carbon Sequestration Regional Partnerships

Climate Change, Copenhagen

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Carbon Sequestration Program Goals

• Deliver technologies & best practices that validate Carbon Capture and Safe Storage (CCSS):
  – 90% CO₂ capture
  – 99% storage permanence
  – < 10% increase in COE (pre-combustion capture)
  – < 35% increase in COE (post- and oxy-combustion)*
  – +/- 30% storage capacity

*This is current estimate – system studies and analysis being conducted and refined to determine appropriate goals
Key Challenges to Carbon Capture and Storage

- Cost of CCS
- Sufficient Storage Capacity
- Permanence
- Best Practices
- Infrastructure

- Regulatory Framework
  - Permitting
  - Treatment of CO₂

- Legal Framework
  - Liability
  - Ownership
    - pore space
    - CO₂

- Public Acceptance

- Human Capital Resources

Program helping to address challenges – either specific project, participation in working groups, or through Regional Partnerships
Sequestration Program Statistics FY2009

Strong industry support
~ 39% cost share on projects

Federal Investment to Date
~ $481 Million

Diverse research portfolio
~ 80 Active R&D Projects
DOE’s Sequestration Program Structure

Core R&D
- Pre-combustion Capture
- Geologic Carbon Storage
- Simulation and Risk Assessment
- CO₂ Use/Reuse
- Monitoring Verification and Accounting
- Demonstration & Risk Assessment
- Global Partnerships/Collaborations
- Infrastructure
  - Regional Carbon Sequestration Partnerships & Other Large Projects
- Commercial Scale Projects
- Existing Plants
  - Post- and Oxy-Combustion Capture
Regional Carbon Sequestration Partnerships
Regional Partnerships Program Phases

FISCAL YEAR


**CHARACTERIZATION PHASE**

Characterize all RCSP regions for carbon capture and storage opportunities

**VALIDATION PHASE**

Validate technologies through field testing at selected geologic and terrestrial site locations

Scale of 100 to 10,000 Tons CO₂

**DEVELOPMENT PHASE**

Complete large-volume development tests of sequestration technologies that will help enable future commercial scale applications

Scale of 1,000,000 Tons CO₂
# Regional Partnerships Participation

160 organization in Phase I

350+ organizations in Phases II and III

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Number</th>
<th>Organizations</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Companies</td>
<td>5</td>
<td>Land Management/Development Company</td>
<td>2</td>
</tr>
<tr>
<td>CO₂ Trading Organizations</td>
<td>3</td>
<td>Law Firm</td>
<td>2</td>
</tr>
<tr>
<td>Coal Companies</td>
<td>8</td>
<td>Local Agencies</td>
<td>4</td>
</tr>
<tr>
<td>Electric Utilities</td>
<td>53</td>
<td>Media/Outreach</td>
<td>6</td>
</tr>
<tr>
<td>Engineering and Research Firms</td>
<td>44</td>
<td>National Laboratories</td>
<td>10</td>
</tr>
<tr>
<td>Environmental NGOs</td>
<td>11</td>
<td>Oil &amp; Gas Companies</td>
<td>37</td>
</tr>
<tr>
<td>Foreign Government Agencies</td>
<td>10</td>
<td>Other State Agencies</td>
<td>51</td>
</tr>
<tr>
<td>Forest Products Companies</td>
<td>4</td>
<td>Pipeline Company</td>
<td>2</td>
</tr>
<tr>
<td>Governmental Advisory Groups</td>
<td>2</td>
<td>State Geologic Surveys</td>
<td>18</td>
</tr>
<tr>
<td>Native American Organizations</td>
<td>4</td>
<td>U.S. Federal Agencies</td>
<td>6</td>
</tr>
<tr>
<td>Industry Trade Groups</td>
<td>22</td>
<td>University and Academic Institutions</td>
<td>47</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>351</strong></td>
<td></td>
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NATIONAL ENERGY TECHNOLOGY LABORATORY
Validation Phase (II) Field Tests

Geologic Field Test Sites
Development Phase (III) Goals

• Assess
  – Injectivity and Capacity
  – Storage Permanence
  – Areal Extent of Plume and Leakage Pathways

• Develop
  – Risk Assessment Strategies
  – Best Practices for Industry

• Engage in Public Outreach and Education

• Support Regulatory Development
Development Phase (III) Timeline

Stage 1.
Site selection and characterization; Permitting and NEPA compliance; Well completion and testing; Infrastructure development

Scale up is required to provide insight into several operational and technical issues that differ from formation to formation

Stage 2.
CO₂ procurement and transportation; Injection operations; Monitoring activities

Stage 3.
Site closure; Post-injection monitoring, Project assessment

RCSP Development Phase- 10 years (FY2008-2018)

~$500 million DOE - over $200 million cost share
Development Phase (III) Injection Schedule

<table>
<thead>
<tr>
<th>Partnership</th>
<th>Formation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Sky PCOR</td>
<td>Saline</td>
</tr>
<tr>
<td>MGSC</td>
<td>Saline</td>
</tr>
<tr>
<td>SECARB</td>
<td>Saline</td>
</tr>
<tr>
<td>WESTCARB</td>
<td>Saline/Oil Bearing</td>
</tr>
<tr>
<td>SWP</td>
<td>Oil Bearing</td>
</tr>
<tr>
<td>PCOR</td>
<td>Saline</td>
</tr>
<tr>
<td>SWP</td>
<td>Saline</td>
</tr>
<tr>
<td>WESTCARB</td>
<td>Saline</td>
</tr>
</tbody>
</table>

Injection Schedule:
- 2009 Injection Scheduled
- 2010 Injection Scheduled
- 2011 Injection Scheduled
Regional Geologic Assessment Atlas-2

- New data on storage formations
  - Offshore capacity, gulf and east

- Methodology for Capacity and \( \text{CO}_2 \) Emissions Estimates and Capacity

- USGS Collaboration

- Federal Lands \( \text{CO}_2 \) Geologic Storage Potential

- \( \text{CO}_2 \) Pipeline Infrastructure

- State \( \text{CO}_2 \) Geologic Storage Potential

- Data now on 10km X 10km grid
CCS Best Practice Manuals

• Phase II (2008-2009)
  – Monitoring Verification and Accounting (Dec 2008)
  – Site characterization (2009)
  – Simulation and Risk Assessment (2009)
  – Well construction and closure (2009)
  – Regulatory Compliance
  – Public Education

• Phase III Updates
CO₂ Injection Regulatory Guidelines

• EPA taking a lead role
  – Guidance released Mar 2007
  – Draft rule summer 2008

• EPA & DOE Working Group

• IOGCC Framework Released
  May 2005

• IOGCC Legal & Regulatory Framework Released in
  September 2007
# Global Partnerships

## Selected DOE Participation in International CO₂ Storage Projects

<table>
<thead>
<tr>
<th>Location</th>
<th>Period (U.S.)</th>
<th>Operations</th>
<th>Reservoir</th>
<th>Operator /Lead Org.</th>
<th>Int’l Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America, Canada Saskatchewan Weyburn-Midale</td>
<td>2000-2009</td>
<td>1.8 mT CO₂/yr commercial 2000</td>
<td>oilfield carbonate EOR</td>
<td>Encana, Apache</td>
<td>IEA GHG R&amp;D Programme, CSLF</td>
</tr>
<tr>
<td>North America, Canada, Alberta Zama oilfield</td>
<td>2005-2009</td>
<td>230,000 tons CO₂, 80,000 tons H₂S demo</td>
<td>oilfield EOR</td>
<td>Apache (Reg. Part.)</td>
<td>CSLF</td>
</tr>
<tr>
<td>North America, Canada, BC Fort Nelson</td>
<td>2009-2015</td>
<td>1.8 mT acid gas/yr (&gt; 1mT CO₂/yr)</td>
<td>Saline</td>
<td>Spectra Energy</td>
<td></td>
</tr>
<tr>
<td>Europe, North Sea Sleipner</td>
<td>2002-2006, 2008-2011</td>
<td>1 mT CO₂/yr commercial 1996</td>
<td>marine sandstone</td>
<td>Statoil</td>
<td>IEA GHG Prog, EC</td>
</tr>
<tr>
<td>Europe, Germany CO₂SINK, Ketzin</td>
<td>2007-2010</td>
<td>60,000-90,000 tonnes CO₂ demo 2008</td>
<td>gas field sandstone</td>
<td>GeoForschungsZentrum, Potsdam</td>
<td>CSLF, European Commission</td>
</tr>
<tr>
<td>Australia, Victoria Otway Basin</td>
<td>2005-2010</td>
<td>100,000 tonnes CO₂ demo 2008</td>
<td>gas field sandstone</td>
<td>CO₂CRC</td>
<td>CSLF</td>
</tr>
<tr>
<td>Africa, Algeria In Salah gas</td>
<td>2005-2010</td>
<td>1 mT CO₂/yr commercial 2004</td>
<td>gas field sandstone</td>
<td>BP, Sonatrach, Statoil</td>
<td>CSLF, European Commission</td>
</tr>
<tr>
<td>Asia, China, Ordos Basin</td>
<td>2008-TBD</td>
<td>assessment phase CCS</td>
<td>Ordos Basin</td>
<td>Shenhua Coal</td>
<td></td>
</tr>
</tbody>
</table>
Summary

• CCS has the potential to offset hundreds of years of CO2 emissions in the United States

• Regional Carbon Sequestration Partnerships are proving CCS throughout most of North America

• Lessons learned from small and large scale field projects will help commercial deployment of CCS technologies

• For the status and results of this program, visit:
  – http://www.fossil.energy.gov
  – http://www.netl.doe.gov