

Achieving Reductions in U.S. Greenhouse Gas Emissions



There Are 2 Methods to Capture or Reduce CO₂ Emissions from Coal Use

1. CO₂ Emissions Reductions:

- Can be achieved today by increasing the efficiency of a plant so less coal is used to produce the same amount of electrical output
- Higher Efficiency = Lower Emissions

2. CO₂ Emissions Capture and Storage:

- Can be achieved in the future by developing advanced coal systems with the equipment necessary to capture CO₂ before it is emitted from the plant

Reducing CO₂ Through Carbon Storage



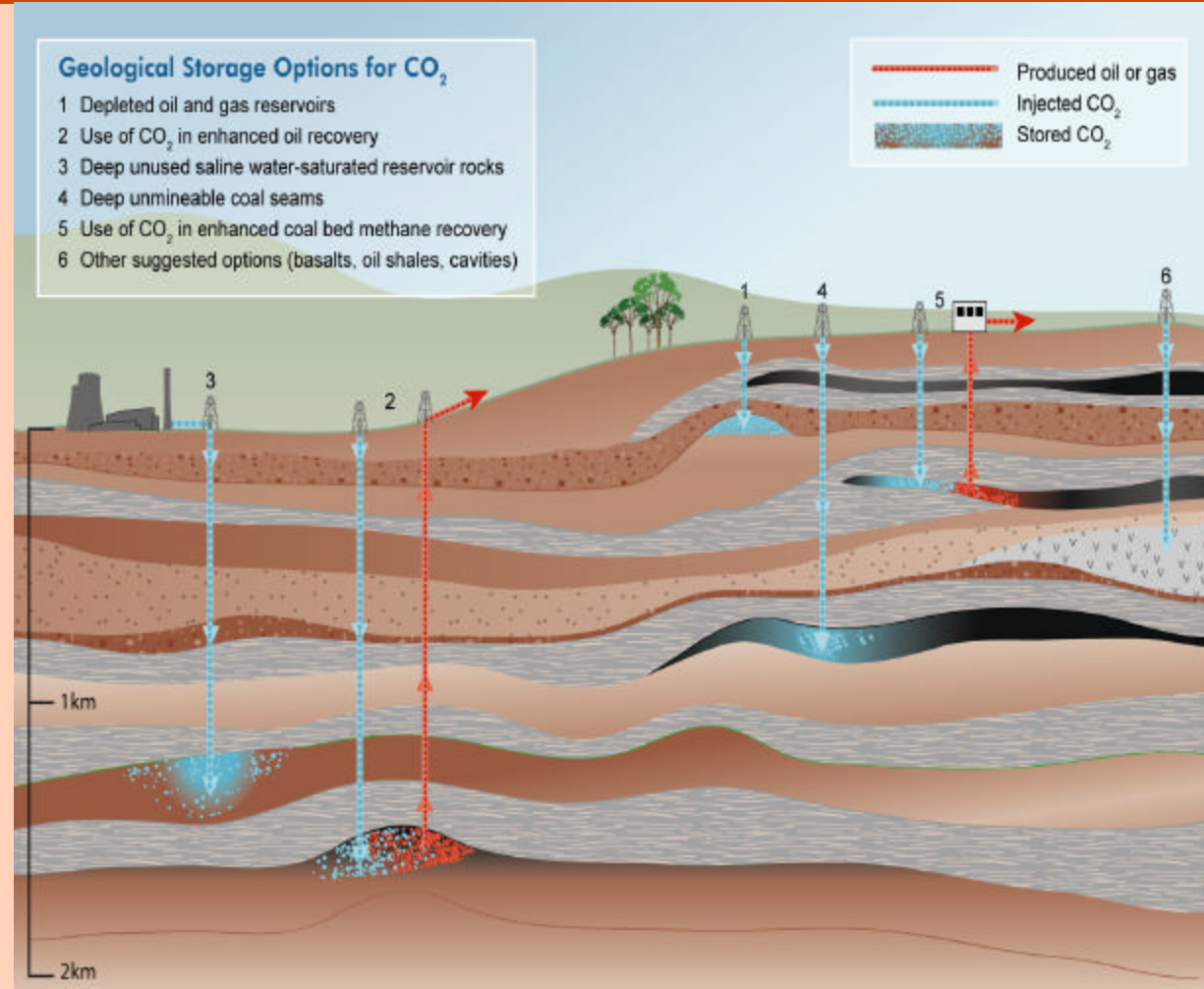
What Can We Do Once We Capture the CO₂?

- **Put it in the bottom of the ocean**
 - Significant environmental uncertainties
- **Make a solid out of it**
 - Large amounts of solids and high energy penalty
- **Utilize it**
 - No use for such a large amount
- **Geologic Storage**
 - May be best solution but has challenges



CO₂ Storage – Main Focus Is Injection into Geological Formations

- **Saline reservoirs**
 - 100's of years capacity
 - Little experience
- **Economical, but lesser capacity options**
 - Depleted oil & gas reservoirs/enhanced oil recovery
 - Unmineable coal beds/enhanced coal-bed methane recovery

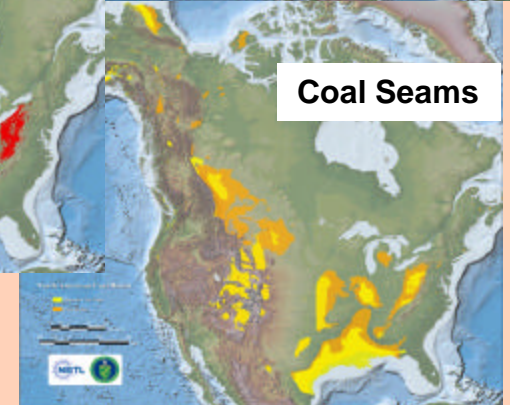
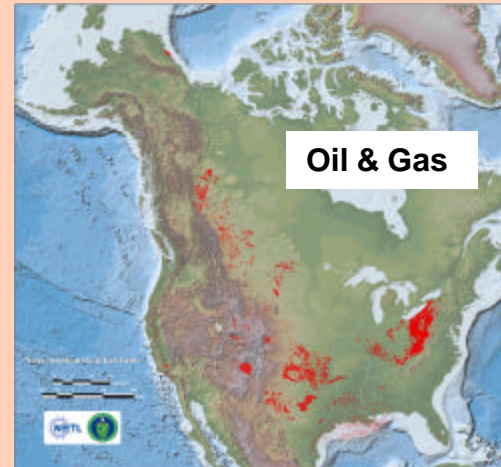
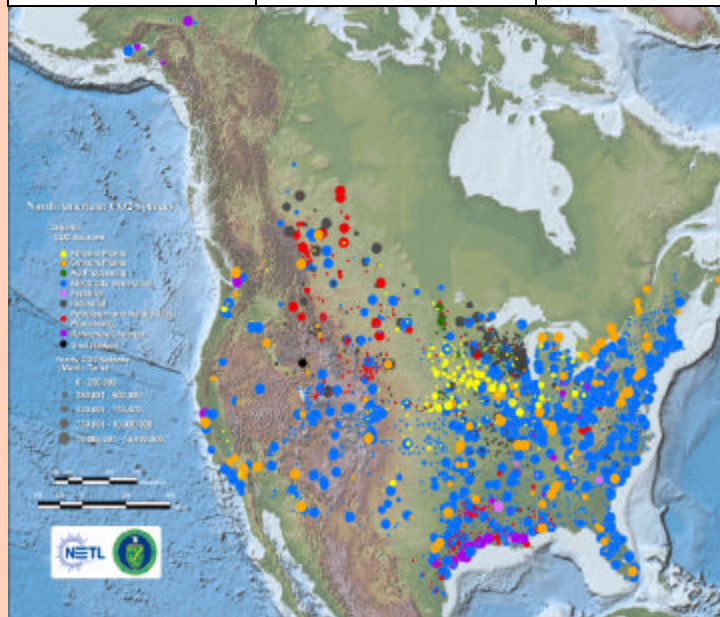


Courtesy of Peter Cook, CO2CRC

Substantial Storage Opportunities in the U.S. Dominated by Saline

CO₂ Sources Documented in NatCarb

CO ₂ Sources	CO ₂ Emission (Million Tons)	Number of Facilities
	3,809	4365



North American CO₂ Storage Potential (Giga Tonnes)

Sink Type	Low	High
Saline	969	3,223
Unmineable Coal Seams	70	97
Oil and Gas Fields	82	83

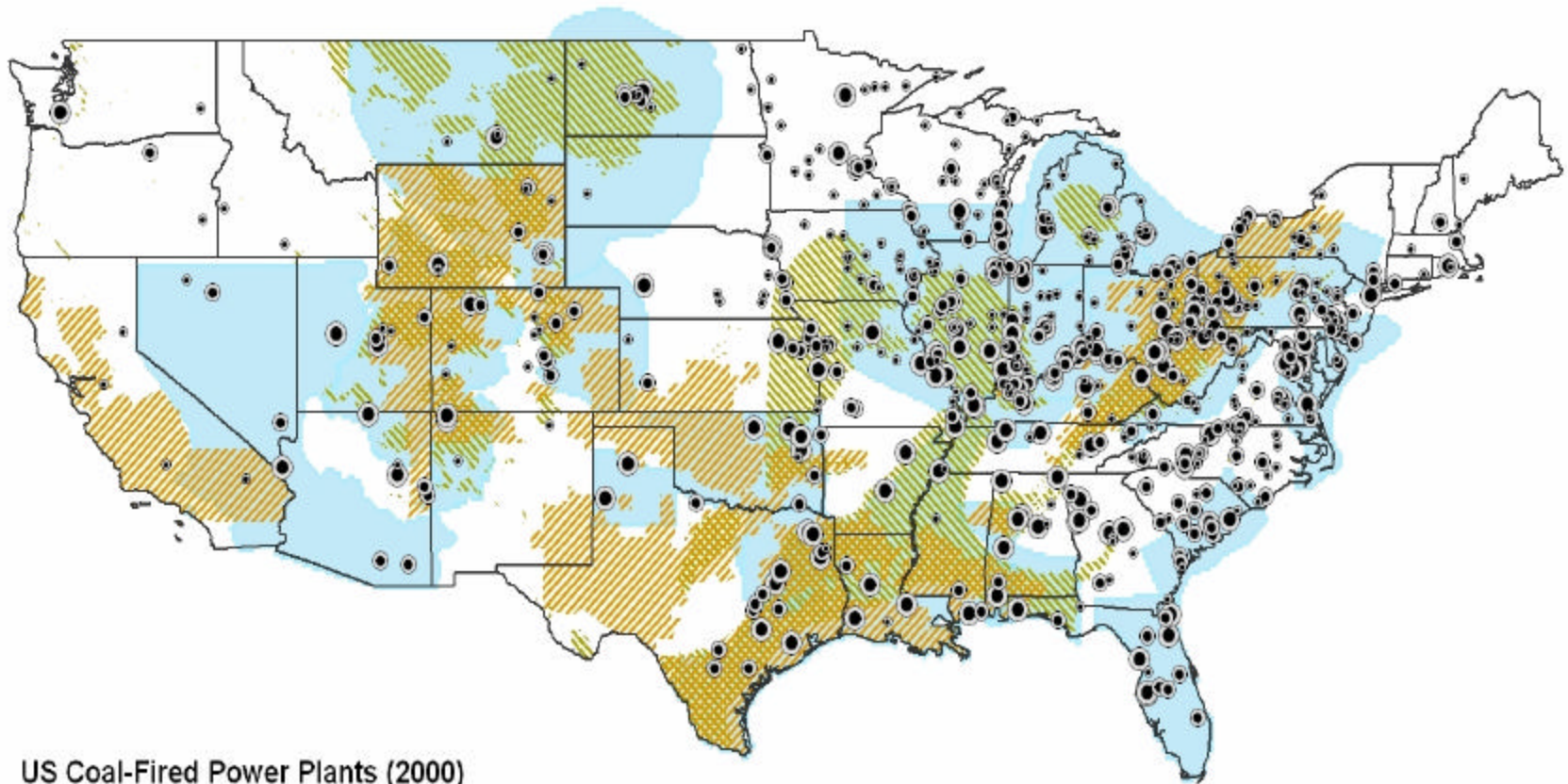
U.S. emits ~ 6 GT CO₂/yr from all sources;
~ 2 GT from coal-fired power plants

Saline Reservoirs Are Available in Most Areas of the U.S.



This map displays saline formation data which were obtained from the RCSPs and other external sources and compiled by NATCARB.

Map Comparing Location of Existing Coal-Fired Power Plants In the U.S. with Potential Sequestration Sites



US Coal-Fired Power Plants (2000)

By Capacity (MW)

• 0 - 250

● 251 - 1000

● 1001 - 4000

Oil & Gas Fields

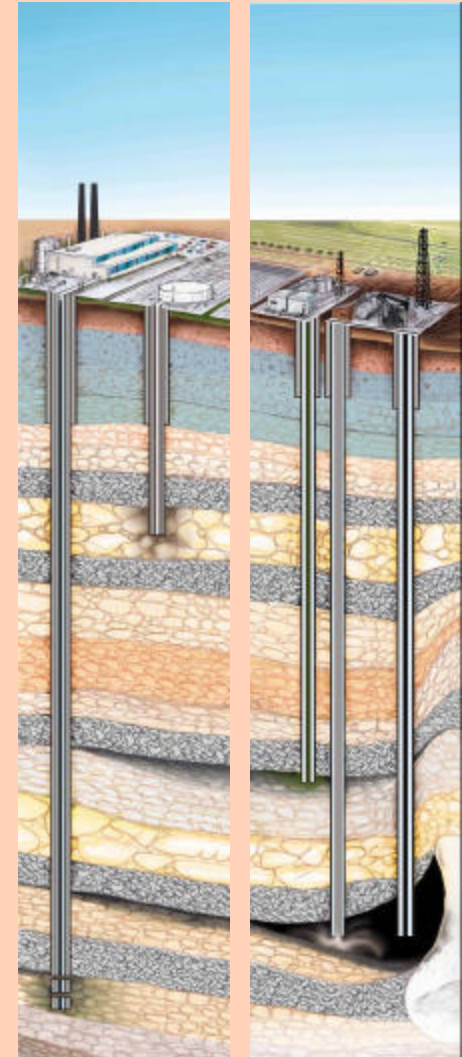
Saline Aquifers

Coalbeds

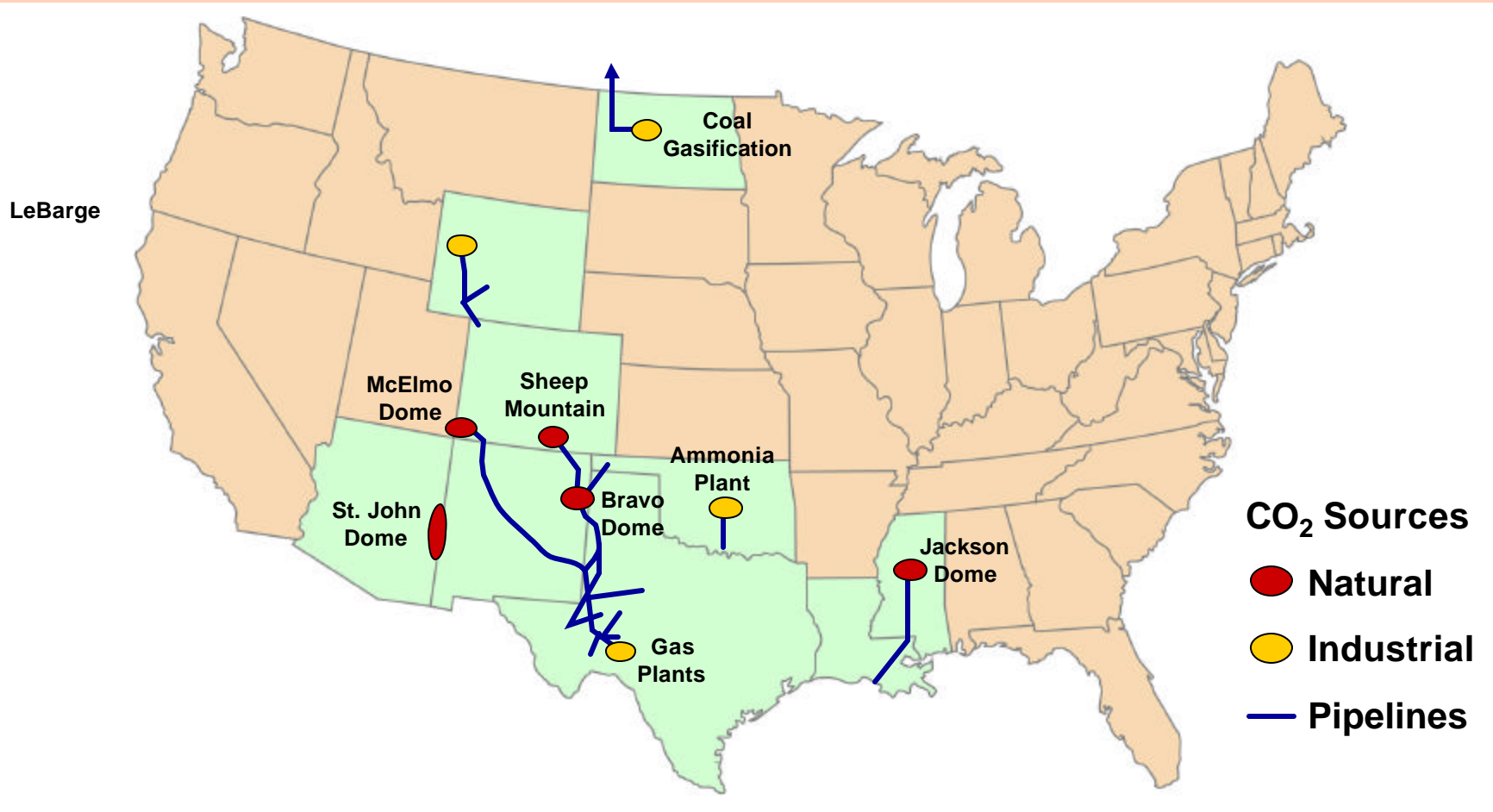
Total Coal-Fired Capacity \approx 330 GW

CO₂ Geologic Storage: Regulatory Risk Uncertain

- **Current experience with CO₂ injection**
 - No significant problems
 - However, experience with generally smaller amounts of CO₂ than needed for coal power plants
- **Regulations controlled by the US EPA Underground Injection Control (UIC) program**
 - May require new injection well type
 - Long term liability not covered in USEPA program
- **Long term liability is a show stopper for projects needed now**



CO₂ Pipelines Have Been A Commercial Technology for 30 Years



2,500+ Miles of CO₂ Pipe in U.S. Today - 350,000 for Natural Gas

May Need Authority for Eminent Domain

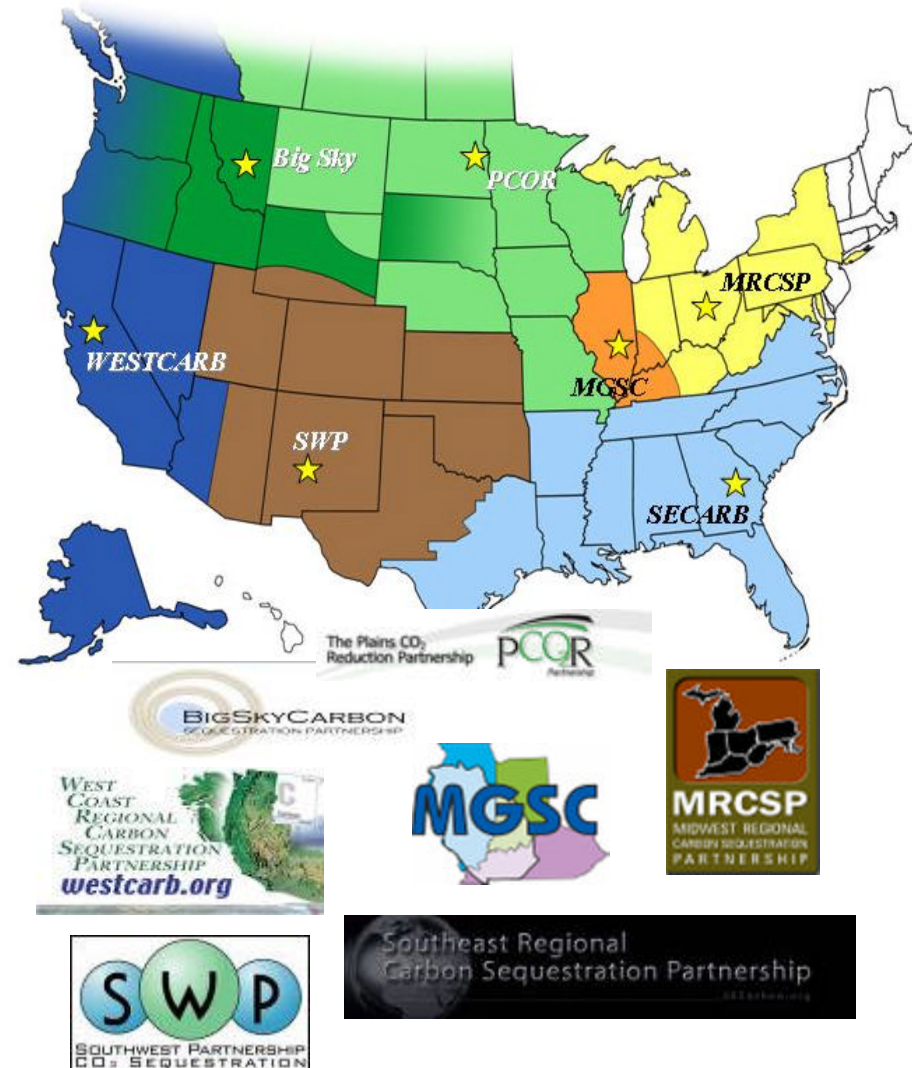
CO₂ Transportation Issues

- The technology (compressors and pipelines) is relatively straightforward but there are some questions:
 - What impurities are allowable?
 - Must it meet current commercial pipeline specifications?
 - Liability transfers?
- At scale, costs are expected to be a small part (<10%) of the overall capture and sequestration costs.
- Key developments for transport systems:
 - Advancement of technologies to monitor and ensure pipeline integrity and safety.



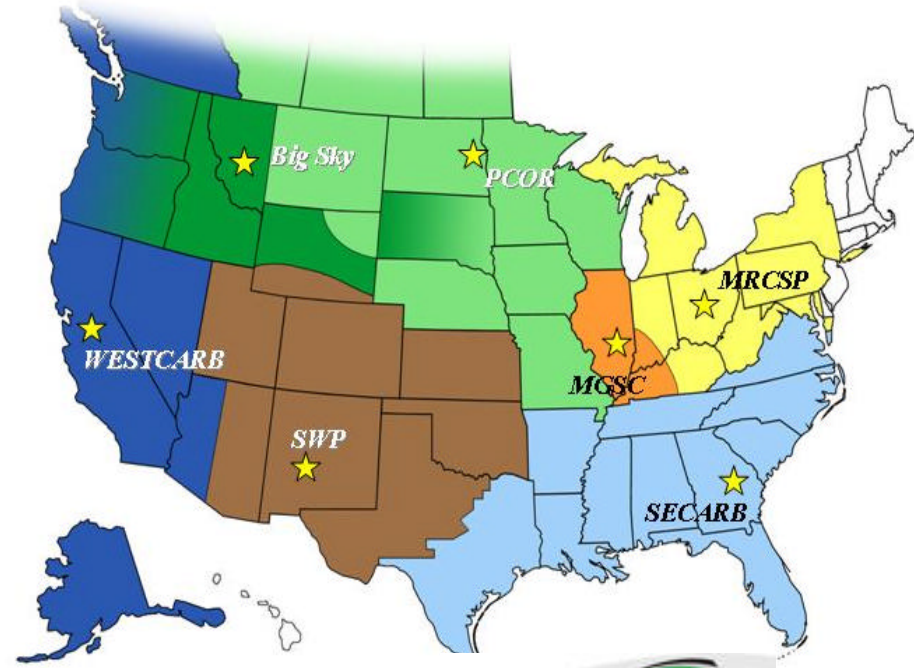
DOE Regional Carbon Sequestration Partnerships – Goals of Program

- Geologic capacity estimates
- Site selection criteria
- Reservoir modeling and validation
- Monitoring, Mitigation, and Verification (MMV)
- Operational considerations
- Economics of sequestration
- Develop Best Practice Management Plans (BPMP)



DOE Regional Carbon Sequestration Partnerships' Activities

- **Characterization Phase**
 - Site characterization
 - 24 months (2003-2005)
- **Validation Phase**
 - 4 years (2005 - 2009)
 - 7 Partnerships (41 states)
 - 25 Geologic field validation tests
 - \$112M DOE funds
- **Deployment Phase**
 - 10 years (2008-2017)
 - Several large injection tests in different geologic reservoirs
 - ~\$100 Million per project



Validation Phase II Goals

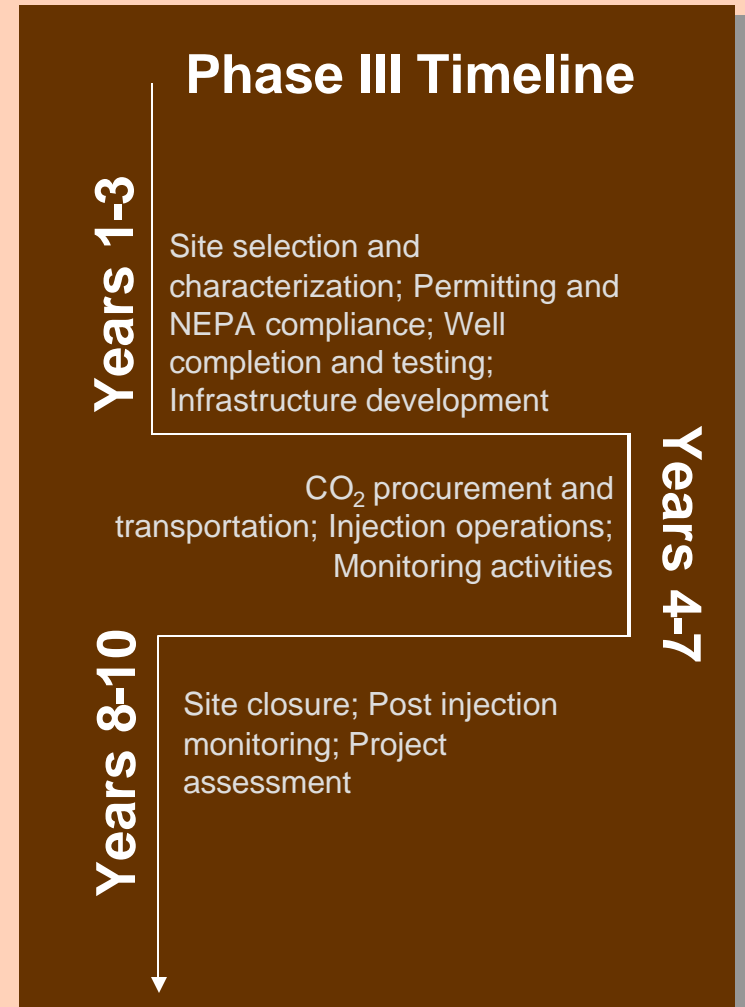
DOE Sequestration Partnerships

- Refine and implement monitoring, mitigation, and verification protocols
- Continue regional characterization
- Perform regulatory compliance activities
- Implement public outreach and education
- Identify commercially available sequestration technologies ready for large scale deployment

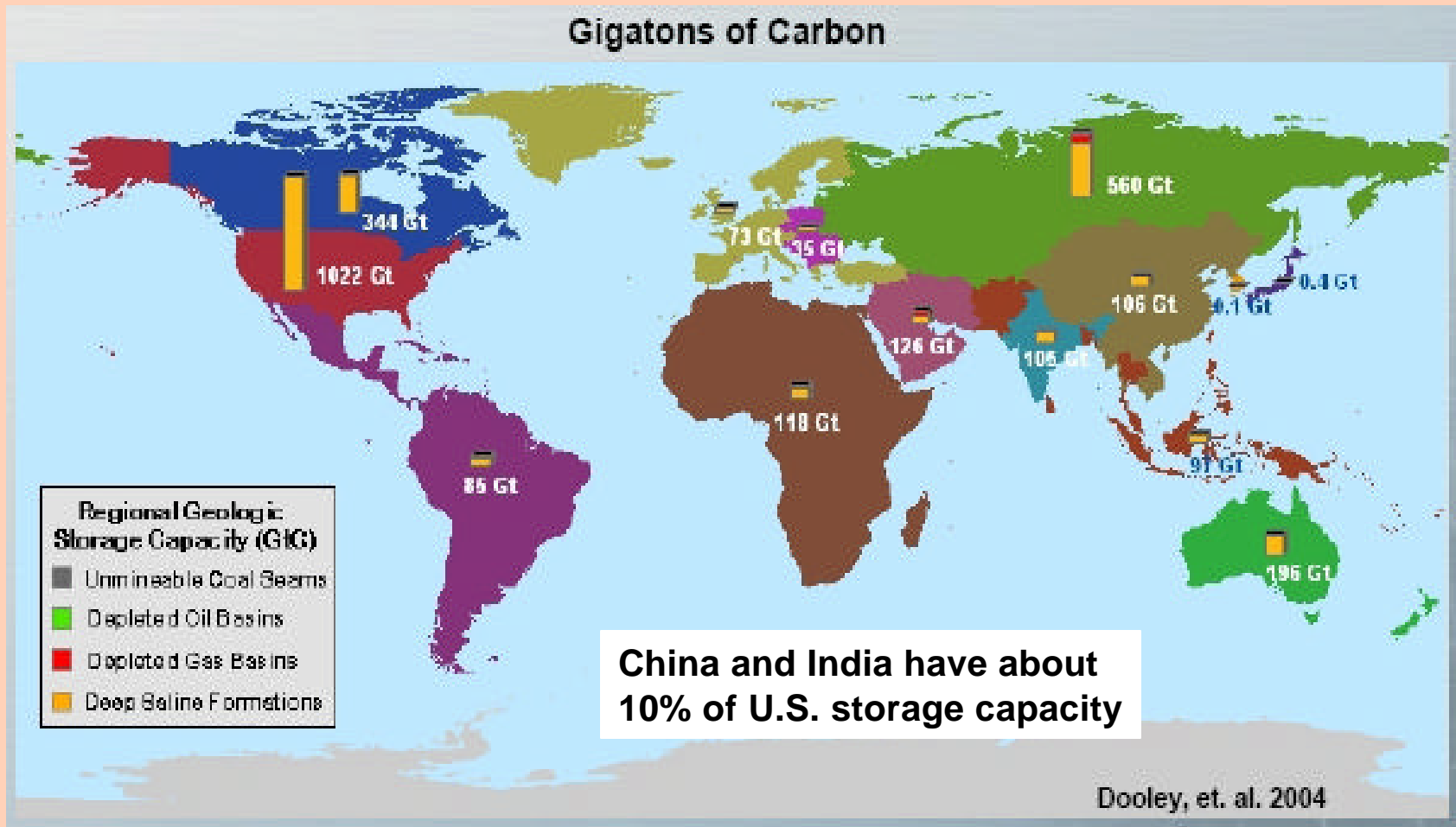
Large Scale Demonstrations Phase III Goals

DOE Sequestration Partnerships

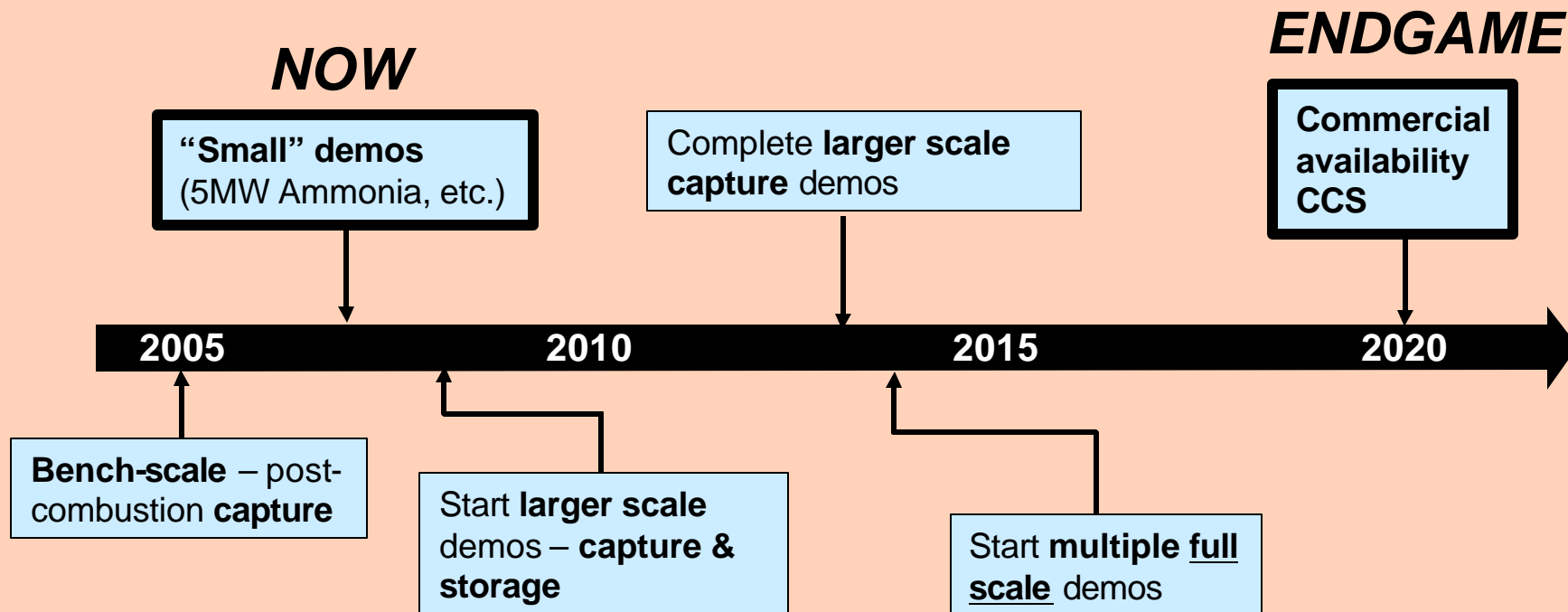
- 10 year program to conduct several large volume sequestration tests in North America
- Site selection and characterization will begin in 2009
- Injection rates up to 1,000,000 tons per year for several years
- Scale up is required to provide insight into several operational and technical issues in different formations



U.S. Storage is Abundant; China and India Storage May Be Limited



Timing for CCS Deployment Requires Aggressive Federal RD&D



Efficiency improvements at existing plants can be implemented now

Needs: Multiple large-scale CAPTURE & STORAGE demos

Timing: 2020 endgame → start today, parallel paths

Realistic? A challenge – technical, policy, funding

What's Needed to Reduce CO₂ Emissions Now and in the Future?

- Efficiency improvements to both the existing fleet and new coal plants to minimize CO₂ emissions
- Cost reductions and efficiency improvements for capture “systems”
- Large scale testing of storage of CO₂ in deep saline reservoirs:
 - >1 million tons of CO₂/year at multiple sites
 - Eliminate permitting uncertainty
 - Address liability issues
- Integrated capture and storage demonstrations₈

With a Concerted RD&D Effort, the Cost Impact of CO₂ Capture Could Decrease Dramatically

- Development of a portfolio of capture technologies is necessary.
- New technologies are being developed
 - Some technologies will be tested at a pilot scale in the next few years;
 - Other advanced technologies are only in laboratory stages of development.
- Efforts need to continue to support the testing and demonstration of these early technologies to accelerate their readiness for deployment.