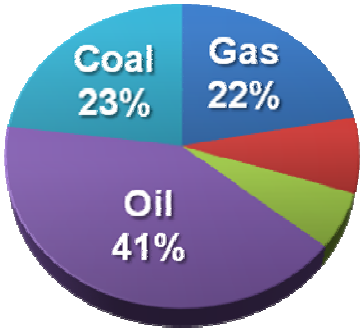
US Clean Coal Research, Development, and Demonstration Programs

NARUC Summer Committee Meetings
Sub-Committee on Clean Coal
July 19, 2009

Joseph Giove III
Senior Program Manager
Office of Fossil Energy

Energy Demand 2006

100 QBtu / Year
85% Fossil Energy

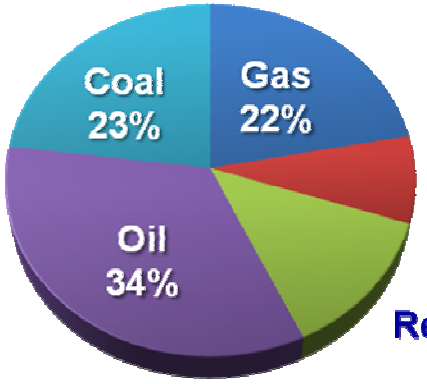


Nuclear 8%

Renewables 6%

Energy Demand 2030

111 QBtu / Year
78% Fossil Energy



Nuclear 8%

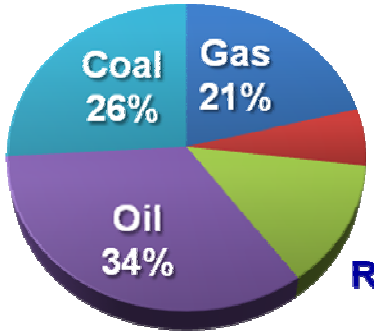
Renewables 13%

+ 11%

United States

675 QBtu / Year
81% Fossil Energy

465 QBtu / Year
81% Fossil Energy

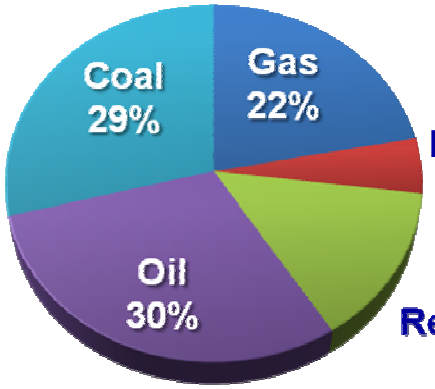


Nuclear 6%

Renewables 13%

+ 45%

World



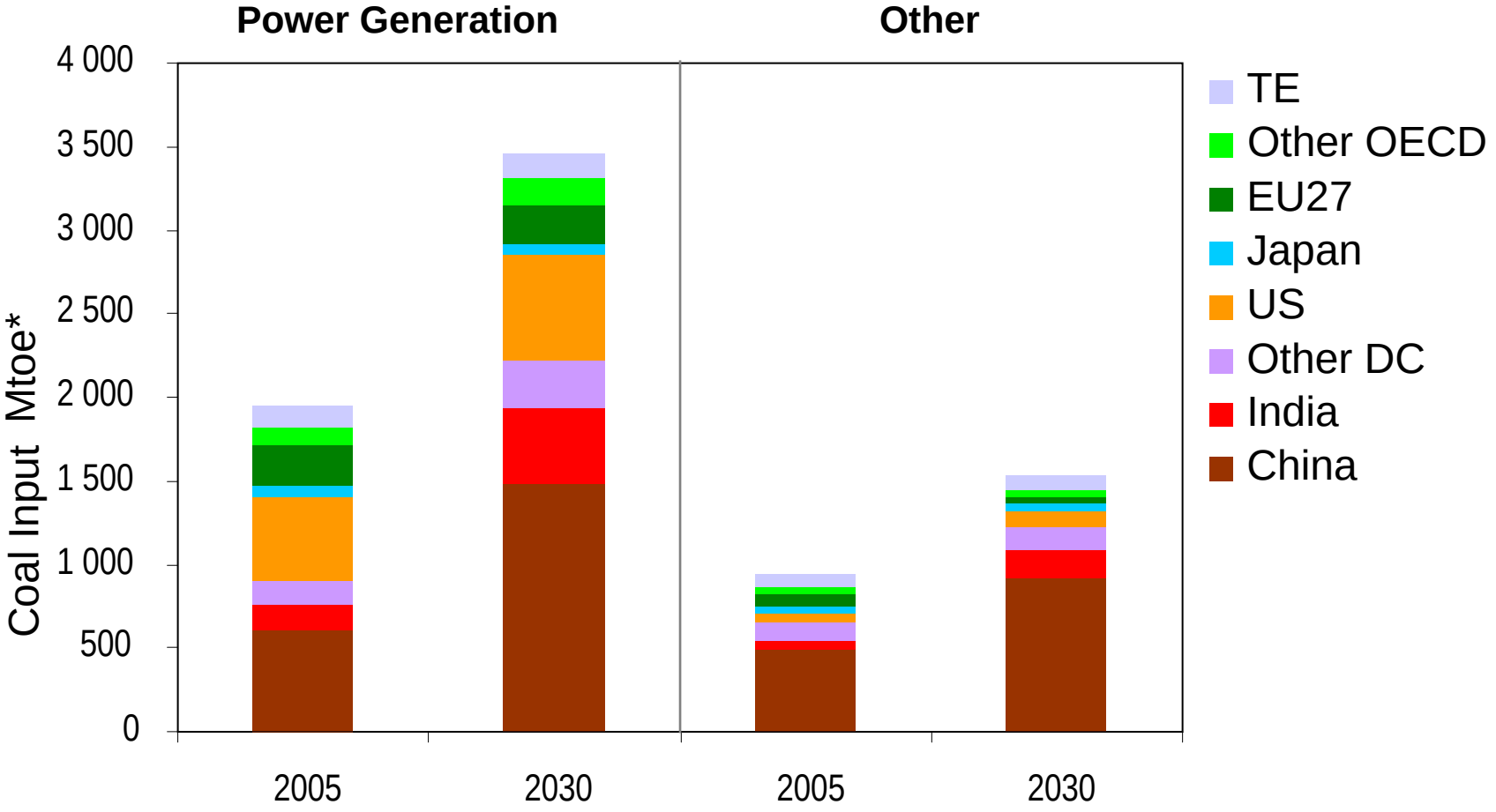
Nuclear 5%

Renewables 14%

Fossil Energy Continues to Provide Vast Majority of Supply

Source: U.S. data from EIA, Annual Energy Outlook 2009 "ARRA" release ; world data from IEA, World Energy Outlook 2008

Importance of Coal World-Wide



Global CO_2 emissions from coal: 11 $GtCO_2$ in 2005, 19 $GtCO_2$ in 2030

** Mtoe: Million metric tonnes oil equivalent*

Source: IEA, World Energy Outlook 2007, Reference Scenario.

Near Zero Emissions Coal

Safe and Effective CCS Technology Deployment

1998 — Research and Development — 2017

CO_2 Sequestration
- Injection Tests
- Monitoring
- Modeling
- Risk Analysis

Advanced Low Cost/Energy CO_2 Capture
- Separation
- Compression
- Power Efficiency
- Capacity Recovery

2009 — Large Scale Demonstrations — 2020

Research Demo
Regional Carbon Sequestration Partnerships

Objectives:
- National Capacity Estimates
- Large Scale CO_2 Injection Tests
- Best Practices Documentation

Near Commercial Demos
CCPI-3 & FutureGen

Objectives:
- Advance CCS Technology
- Integrated CCS Demo addressing siting and permitting
- Standards

2015 — Early Deployment – Full Commercial Deployment — 2025

Deployment Incentives
- Advanced Demos
- Tax Credits
- Loan Guarantees

Clean Coal Funding, FY07-FY09

($ in thousands)	FY 2007 Adjusted B/A	FY 2008 Adjusted B/A	FY 2009 Omnibus
Demos			
CLEAN COAL POWER INITIATIVE	58,758	67,444	288,174
FUTUREGEN	52,504	72,262	0
R&D			
FUELS AND POWER SYSTEMS			
Innovations for Existing Plants	15,626	35,083	50,000
Advanced IGCC	55,468	52,029	65,236
Advanced Turbines	19,475	23,125	28,000
Carbon Sequestration	97,228	115,620	150,000
Fuels	21,513	24,088	25,000
Fuel Cells	61,653	53,956	58,000
Advanced Research	32,213	36,264	28,000
Subtotal, Fuels and Power Systems	303,176	340,165	404,236
TOTAL COAL	414,438	479,871	692,410

American Recovery and Reinvestment Act of 2009 (Stimulus) Funding Summary

Program/Project Activity	($ in thousands)
Fossil Energy R&D (FutureGen)	1,000,000
Clean Coal Power Initiative (CCPI) - Round 3	800,000
CCS from Industrial Sources	1,520,000
Site Characterization	50,000
Regional Sequestration Training and Research	20,000
Fossil Energy Program Direction	10,000
Total	3,400,000

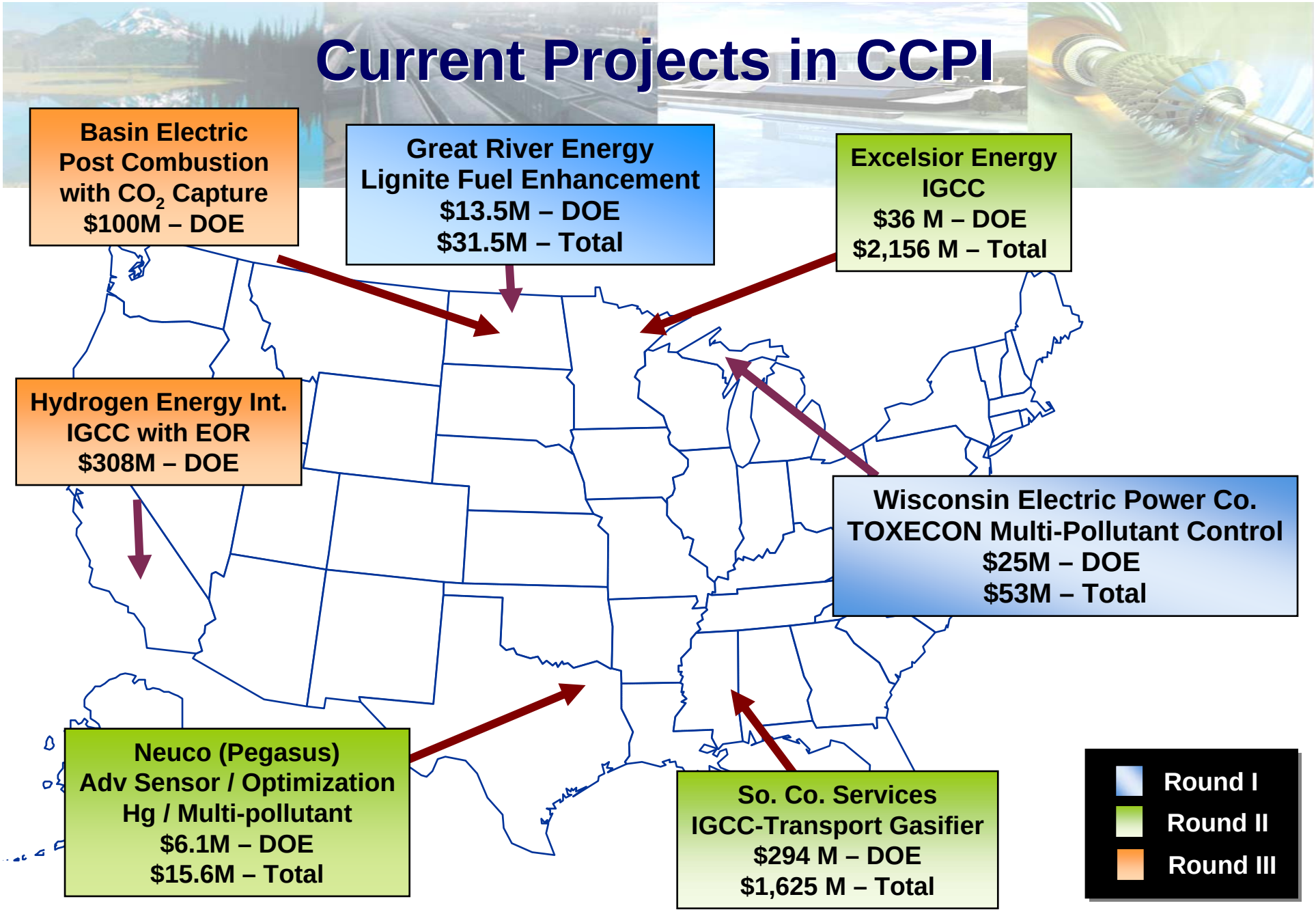
Clean Coal Power Initiative (CCPI) Large Scale Demos:

- **CCPI is a cooperative, cost-shared program between the government and industry which will demonstrate advanced coal-based power generation technologies including carbon capture and storage.**
  - **CCPI – Round I (announced in January 2003)**
    - **8 projects selected**
      - **2 projects withdrew (Colorado Springs, LG&E)**
      - **2 projects are ongoing (WE Energies, GRE)**
      - **3 projects discontinued before or during project development (WMPI, University of Kentucky, Western Greenbrier)**
      - **1 project has been completed (Neuco)**
  - **CCPI – Round II (announced in October 2004)**
    - **4 projects selected**
      - **1 project withdrew (Peabody Mustang)**
      - **2 projects awarded and in project development (Mesaba, Southern)**
      - **1 project is in operation (Pegasus)**
  - **CCPI – Round III (announced in June 2009)**
    - **2 projects selected so far (Basin Electric, Hydrogen Energy International)**

CCPI - Round 3

- **Focus: The third round of CCPI projects is focused on advanced power with capability for capture or beneficial reuse of CO2**
- **Goal: Getting new, potential low-cost and efficient technologies that mature from the R&D sub-pilot scale to test in demonstrations for clean coal while integrating promising Carbon Capture and Storage technologies for commercial scale demonstration.**
- **CCPI-3 will require:**
  - **Minimum operation of ≥ 90% carbon capture efficiency**
  - **Minimum capture and sequestration of ≥ 300,000 tons CO_2/year**
  - **Projects must use domestic mined coal or coal refuse for at least 75% of energy input**
  - **Minimum 50% cost share from participant in the demonstration; statute requires up front funding; no more than 25% cost growth in DOE share may be considered.**
  - **Targeting COE increases of**
    - **< 10% for gasification**
    - **< 35% for combustion & oxy-combustion**
  - **Potential power systems include**
    - **Pre-combustion, post-combustion, oxy-combustion**
  - **Geologic storage options include**
    - **Saline aquifer injection, EOR, coal seams, basalt, stacked storage**

Current Projects in CCPI



Hydrogen Energy International

Commercial Demonstration of Advanced IGCC with Carbon Capture

- 257 MWe (net) IGCC in Kern County, CA
- 90% CO_2 capture (2,000,000 tons/year) sequestered in an EOR application
- DOE $308 million
- Construction start: March 2011
- Demonstration start: 2015

IGCC with Hydrogen Turbine and Full Integrated Carbon Capture & Sequestration

Basin Electric Power Cooperative
Antelope Valley Station CO_2 Capture and Sequestration

- Antelope Valley Station (AVS) near Beulah, ND
- 120 MW-equivalent slipstream from AVS Unit 1
- 90% CO_2 capture (1,000,000 tons/year) for sequestration (EOR)
- Ammonium sulfate for reuse
- Approx. $300 million (DOE $100 million)
- Construction start: February 2010
- Demonstration start: January 2013

Lignite-Based Boiler Post-Combustion CO_2 Capture using Powerspan ECO_2® Technology

Recovery Act: Expand & Extend Clean Coal Power Initiative Round 3

- **Objectives**
  - **Demonstrate CO_2 capture & sequestration at coal-based power facilities; ≥300,000 tons CO_2 per year**
  - **Includes pre- & post-combustion CO_2 capture, oxycombustion**
  - **Targets saline, EOR, ECBM, basalt, stacked storage & beneficial use**

- **CCPI-3 re-opened, amended to establish a 2nd closing date**
  - **$1.43 billion incl. Recovery Act & CCPI funds**
  - **Planned awards ~ 6-7 total**

- **1st closing date for applications: Jan. 20, 2009**
  - **Capture efficiency ≥ 90%; Coal use ≥ 75%**
  - **Selections announced on July 1, 2009**
  - **Funds not used will be available for 2nd closing**

- **2nd closing date for applications: Aug. 24, 2009**
  - **Funding Opportunity Announcement issued June 9, 2009**
  - **Capture efficiency ≥ 50%, target 90%; Coal use ≥ 55%**
  - **Applicants not selected under 1st closing date must re-submit**

FutureGen

FutureGen Goals:

- To emit virtually no air pollutants
- Integrate full-scale operations – a key step
- Serve as a test facility for emerging technologies
- Capture & permanently sequester at least 1 million metric tons/year CO_2

FutureGen Path Forward:

- DOE to pursue the FutureGen project in Mattoon, Illinois with the FutureGen Industrial Alliance
- DOE to contribute $1.073 Billion ($1 billion ARRA funds)
- The following activities will be pursued:
  - A rapid restart of preliminary design activities
  - Completion of a site-specific preliminary design and updated cost estimate
  - Expansion of the Alliance sponsorship group
  - Development of a complete funding plan
  - Potential additional subsurface characterization

Regional Carbon Sequestration Partnerships

Creating Infrastructure for Wide Scale Deployment:

Characterization Phase

- 24 months (2003-2005)

Validation Phase

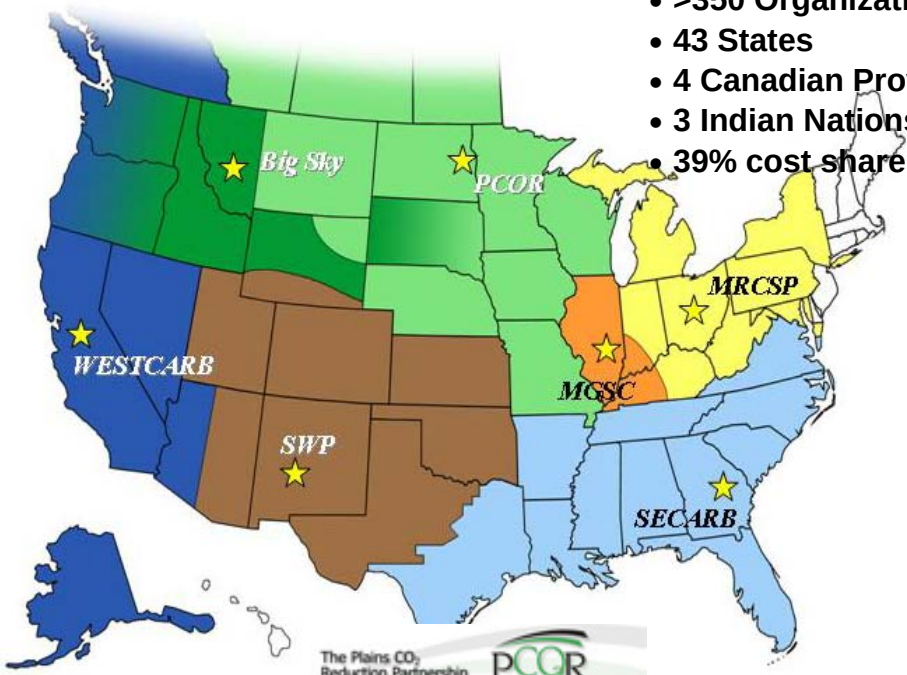
- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 25 Geologic field validation tests

Deployment Phase

- 10 years (2008-2017)
- Several large injection tests in different geology

Representing:

- >350 Organizations
- 43 States
- 4 Canadian Provinces
- 3 Indian Nations
- 39% cost share



The Plains CO_2 Reduction Partnership

PCOR Partnership

BIG SKY CARBON SEQUESTRATION PARTNERSHIP

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP
westcarb.org

MGSC

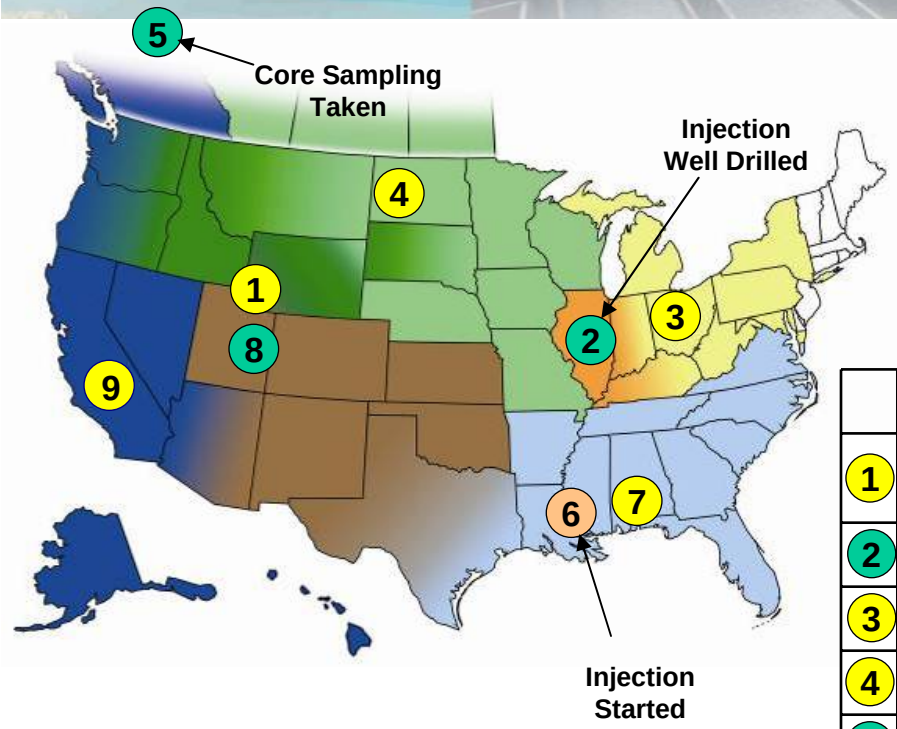
MRCSP
MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

SWP
SOUTHWEST PARTNERSHIP CO_2 SEQUESTRATION

Southeast Regional Carbon Sequestration Partnership

RCSP Phase III: Development

Large-Volume Geologic Field Tests



- ✓ *Nine large-volume tests*
- ✓ *Injections initiated 2009 – 2011*

	Partnership	Geologic Province	Type
1	Big Sky	Triassic Nugget Sandstone / Moxa Arch	Saline
2	MGSC	Deep Mt. Simon Sandstone	Saline
3	MRCSP	Shallow Mt. Simon Sandstone	Saline
4	PCOR	Williston Basin Carbonates	Oil Bearing
5		Devonian Age Carbonate Rock	Saline
6	SECARB	Lower Tuscaloosa Formation Massive Sand Unit	Saline
7			
8	SWP	Regional Jurassic & Older Formations	Saline
9	WESTCARB	Central Valley	Saline

- 2009 Injection Scheduled
- 2010 Injection Scheduled
- 2011 Injection Scheduled

RCSP - Phase III Projects

- **Plains CO_2 Reduction Partnership (10/9/07)**
  - Led by University of North Dakota's Energy and Environmental Research Center (EERC)
    - Alberta Basin (deep saline) & Williston Basin (EOR and CO_2 in deep carbonate/saline)
    - CO_2 from gas production facility
    - Total Project Cost: $135.6M (DOE Share: 67M)

- **SE Regional Carbon Sequestration Partnership (10/9/07)**
  - Led by Southern States Energy Board (SSEB)
    - Lower Tuscaloosa Formation Massive Sand Unit (Deep saline)
    - CO_2 from post combustion coal, and oil & gas operator
    - Total Project Cost: $93.7M (DOE Share: 65M)

- **SW Regional Partnership for Carbon Sequestration (10/9/07)**
  - Coordinated by the New Mexico Institute of Mining and Technology
    - Jurassic-age Entrada Sandstone Formation
    - CO_2 from a natural CO_2 deposit
    - Total Project Cost: $88.8M (DOE Share: 65M)

RCSP - Phase III Projects

- **Midwest Geologic Sequestration Consortium (12/18/07)**
  - Coordinated by Illinois State Geologic Survey (University of Illinois)
    - Mount Simon Sandstone Formation in Illinois
    - CO_2 from natural gas processing plant or “natural vents”
    - Total Project Cost: $84.3M (DOE Share: 67M)

- **Midwest Regional Carbon Sequestration Partnership (5/6/08)**
  - Led by Battelle Memorial Laboratories
    - Mount Simon Sandstone Formation
    - CO_2 from an ethanol production facility
    - Total Project Cost: $92.8M (DOE Share: 61.1M)

- **West Coast Regional Carbon Sequestration Partnership (5/6/08)**
  - Led by the California Energy Commission
    - San Joaquin Basin in Central California
    - CO_2 from natural or synthetic gas plant (oxyfuel)
    - Total Project Cost: $90.6M (DOE Share: 65.6M)

RCSP - Phase III Projects

- **Big Sky Regional Carbon Sequestration Partnership (11/17/08)**
  - **Led by Montana State University-Bozeman**
    - **Riley Ridge Unit on the LaBarge Platform in SW, Wyoming**
    - **CO_2 from Cimarex Energy's planned helium and natural gas processing plant**
    - **Total Project Cost: $130.6M (DOE Share: 66.9M)**

Final Summary and Observations

- The United States continues to be a very active investor in clean coal technology
- There is currently a significant focus on carbon capture and storage (CCS)
- Technology is available today for carbon capture from new and retrofitted coal-fired IGCC and PC power plants, however:
  - It is very expensive
  - Parasitic load is very high
  - Reliability needs to be proven
- DOE RD&D program is targeting the key issues
  - Lower cost, advanced technology (R&D program)
  - Proving sequestration (sequestration program, Regional Partnerships)
  - Integration (FutureGen and CCPI)