

# Update on US Clean Coal Research, Development, and Demonstration Programs



**NARUC Winter Committee Meetings  
Sub-Committee on Clean Coal  
February 14, 2010**

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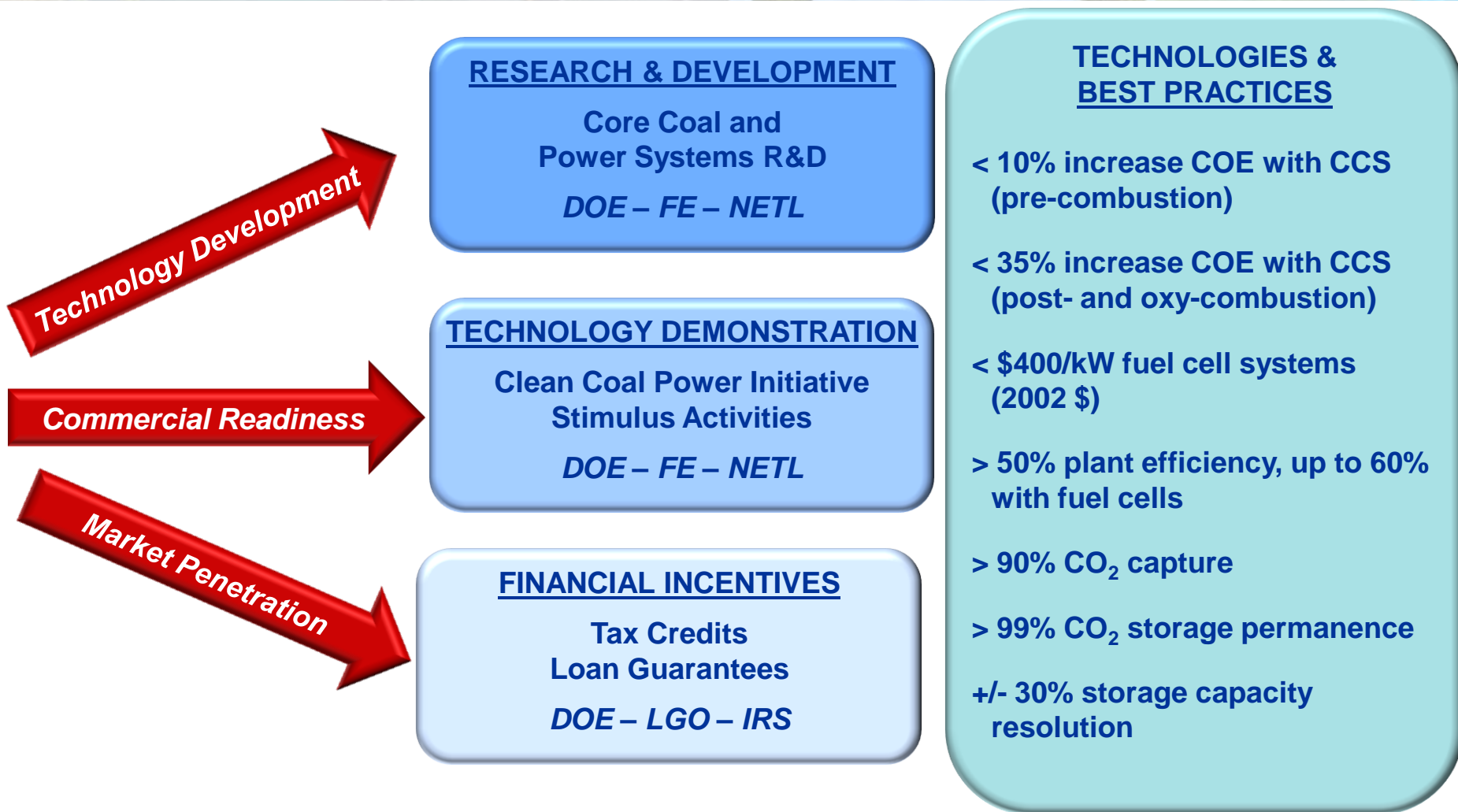


# Government's Coal RD&D Investment Strategy

*Approaches*

*Programs*

*Goals*



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

<b>Program/Project Activity</b>	<b>(\$ in thousands)</b>
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
<b>Total</b>	<b>3,400,000</b>

# Clean Coal Funding, FY08-FY10

	FY 2008	FY 2009	FY2010	
(\$ in thousands)	Adjusted B/A	Omnibus	Conference	
<b>Demos</b>	<b>CLEAN COAL POWER INITIATIVE</b>	<b>67,444</b>	<b>288,174</b>	<b>0</b>
	<b>FUTUREGEN</b>	<b>72,262</b>	<b>0</b>	<b>0</b>
<b>R&amp;D</b>	<b>FUELS AND POWER SYSTEMS</b>			
	<b>Innovations for Existing Plants</b>	<b>35,083</b>	<b>50,000</b>	<b>52,000</b>
	Advanced IGCC	52,029	65,236	63,000
	Advanced Turbines	23,125	28,000	32,000
	<b>Carbon Sequestration</b>	<b>115,620</b>	<b>150,000</b>	<b>154,000</b>
	Fuels	24,088	25,000	25,000
	Fuel Cells	53,956	58,000	50,000
	Advanced Research	36,264	28,000	28,000
	<b>Subtotal, Fuels and Power Systems</b>	<b>340,165</b>	<b>404,236</b>	<b>404,000</b>
	<b>TOTAL COAL</b>	<b>479,871</b>	<b>692,410</b>	<b>404,000</b>



# Clean Coal Power Initiative (CCPI) Current Status

- **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.**
- **Demonstration projects represent technologies ready for commercial entry are competitively selected with requirement of at least 50% cost share from industry**
  - **CCPI – Round I (announced Jan 2003) – 8 projects selected**
    - 5 projects withdrew or were discontinued
    - 1 project is ongoing
    - 2 projects are complete
  - **CCPI – Round II (announced Oct 2004) – 4 projects selected**
    - 1 project withdrew
    - 2 projects awarded and in design/permitting
    - 1 project is in operation
  - **CCPI – Round III (announced Aug 2008/Dec 2009) – 5 projects selected**
    - 2 projects in negotiation
    - 3 project awarded and in design/permitting

# Current Projects in CCPI



**Basin Electric**  
Post Combustion  
with CO<sub>2</sub> Capture  
\$100M - DOE

**Great River Energy**  
Lignite Fuel Enhancement  
\$13.5M - DOE  
\$31.5M - Total

**Excelsior Energy**  
IGCC  
\$36M - DOE  
\$2,156M - Total

**Hydrogen Energy California**  
IGCC with EOR  
\$308M - DOE  
\$2,840M - Total

**AEP Mountaineer**  
Post Combustion  
with CO<sub>2</sub> Capture  
\$334M - DOE  
\$668M - Total

**Summit Texas Clean Energy**  
IGCC with EOR  
\$350M - DOE  
\$1,727M - Total

**So. Co. Services**  
IGCC-Transport Gasifier  
\$294M - DOE  
\$1,625M - Total

**Neuco (Pegasus)**  
Sensor & Control Optimization  
\$6.1M - DOE  
\$15.6M - Total

**Southern Company**  
Post Combustion  
with CO<sub>2</sub> Capture  
\$295M - DOE

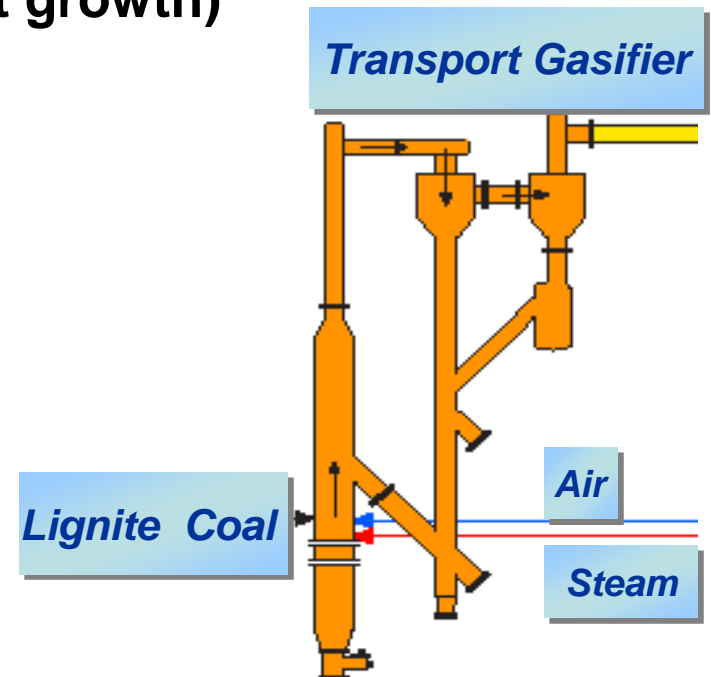
Legend for project rounds:

- Round I (Blue box)
- Round II (Green box)
- Round III (Orange box)

# Southern – Kemper County IGCC Overview

- Demonstration of a Coal-Based Transport Gasifier (582 MWe net)
- IGCC facility will be constructed in Kemper County, MS
- 67% CO<sub>2</sub> capture and resale for EOR (not part of original project)
- Total - \$1.6 billion  
DOE - \$294 million (includes 25% cost growth)

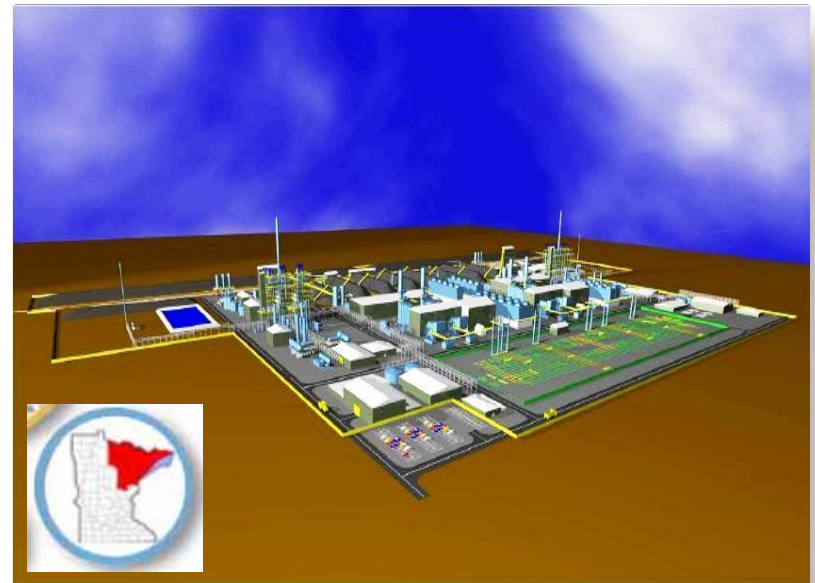
- Project Awarded – Jan 2006
- Project moved to MS – Dec 2008
- Construction – June/July 2010
- Operations – May 2014



# Excelsior/Mesaba IGCC Overview

- Demonstrate ConocoPhillips E-Gas™ technology in a large-scale commercial IGCC application
- IGCC facility would be constructed in northeastern MN
- Nominal 600 MWe net (770 MW nameplate gross) with optional CO<sub>2</sub> management plan (not in DOE scope)
- Total - \$2.156 billion  
DOE - \$ 36 million

- Project Awarded – June 2006
- Construction – July 2011
- Operations – July 2015



# Hydrogen Energy California IGCC Overview

- Demonstrate a 257 MWe (net) IGCC with CCS
- IGCC facility will be constructed in Kern County, CA.
- 90% CO<sub>2</sub> capture (2,000,000 tons/year) sequestered in an EOR application
- Total - \$2.84 billion  
DOE - \$308 million

- Conditional Award: 9/30
- Construction: February 2012
- Operations: November 2016

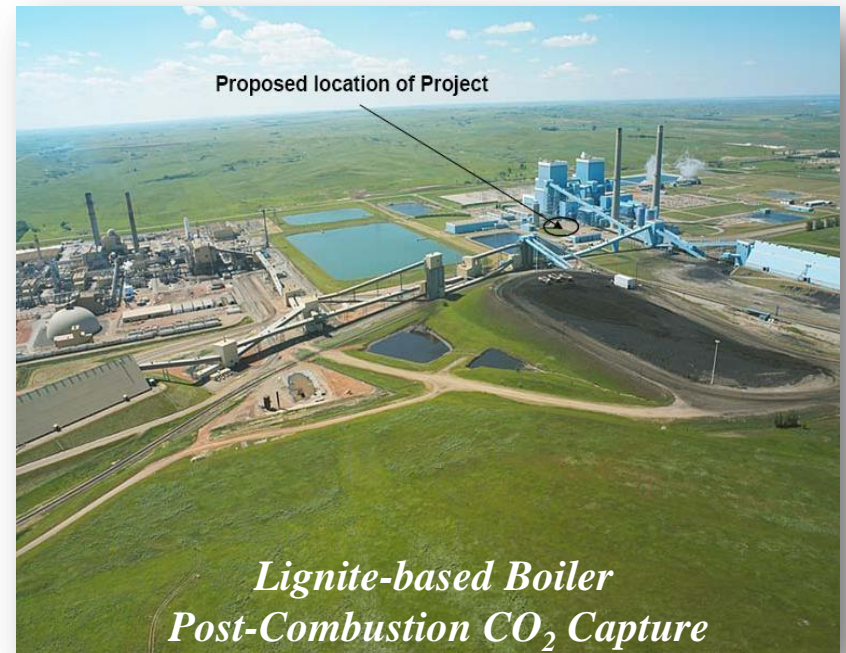


*IGCC with Hydrogen Turbine and Full  
Integrated Carbon Capture & Sequestration*

# Basin Post Combustion CO<sub>2</sub> Capture Overview

- Demonstrate integrated post combustion CO<sub>2</sub> Capture, Transport and Storage
- Antelope Valley Station (AVS) near Beulah, ND
- 90% CO<sub>2</sub> capture from 120 MW-equivalent slipstream
- Total - \$287 million (proposed)  
DOE - \$100 million

- FEED: 6-9 Months (Jan 2010)
- Construction: March 2011
- Operations: October 2013



# AEP: Post Combustion CO<sub>2</sub> Capture

- **Demonstrate a viable post combustion CO<sub>2</sub> capture system at commercial scale**
- **Appalachian Power's Mountaineer Plant (New Haven, WV)**
- **90% CO<sub>2</sub> capture (1,500,000 tons/year) sequestration in a deep saline aquifer.**
- **Total - \$668 million  
DOE - \$334 million**

- **Conditional Award : January 2010**
- **Construction: January 2013**
- **Operation: December 2015**



# Southern Post Combustion CO<sub>2</sub> Capture Overview

- **Demonstrate Integrated CO<sub>2</sub> Capture, Transport and Sequestration with Monitoring, Verification and Accounting (MVA)**
- **Alabama Power's Plant Barry (north of Mobile, AL.)**
- **90% CO<sub>2</sub> capture (1,000,000 metric tons/yer) from a 160 MW equivalent flue gas stream**
- **Total - \$665 million (proposed)**  
**DOE - \$295 million**

- **Award targeted: Jan 31, 2010**
- **Construction: June 5, 2013**
- **Operation: October 1, 2015**



# Summit Texas Clean Energy: IGCC with EOR

- Demonstrate large-scale commercial IGCC (400 MWe) with CCS
- IGCC facility will be constructed near Odessa/Midland, TX.
- 90% CO<sub>2</sub> capture (3,000,000 tons/year) sequestered in an EOR application
- Total - \$1,726 million  
DOE - \$350 million

- Conditional Award: January 2010
- Construction: October 2010
- Operation: July 2014



# 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<sub>2</sub>

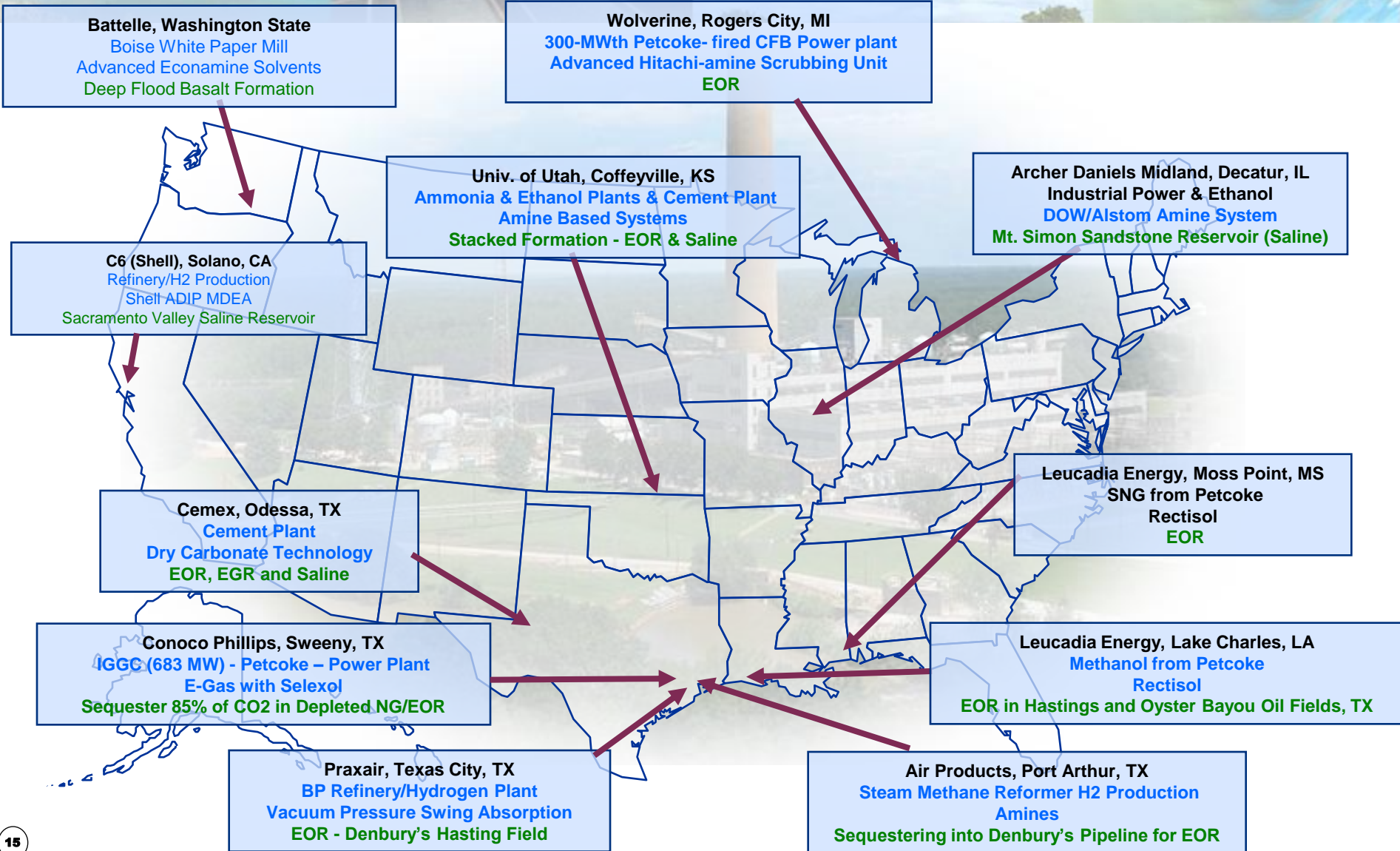


## FutureGen Path Forward:

- 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 are being pursued or have been completed:
  - Preliminary design activities
  - 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

# Industrial CCS Project Locations

## Large-scale CCS from Industrial Sources (Area 1)





# Industrial CCS Project Locations

Large-scale CCS from Industrial Sources (Area 1)

## Objectives

- Demonstrate advanced CCS technologies
- To progress beyond the R&D stage of readiness
- Integration with comprehensive Monitoring, Verification & Accounting (MVA)
- Demonstrate sequestration option

## Target

- Industrial sources
- Industries may produce heat, fuels, chemicals, hydrogen or other useful products with or without electricity production
- 1MM tons/yr of CO<sub>2</sub> emission from each plant for CCS

# Regional Carbon Sequestration Partnerships

**Creating Infrastructure  
for Wide Scale Deployment:**

## Characterization Phase

- 24 months (2003-2005)

## Validation Phase

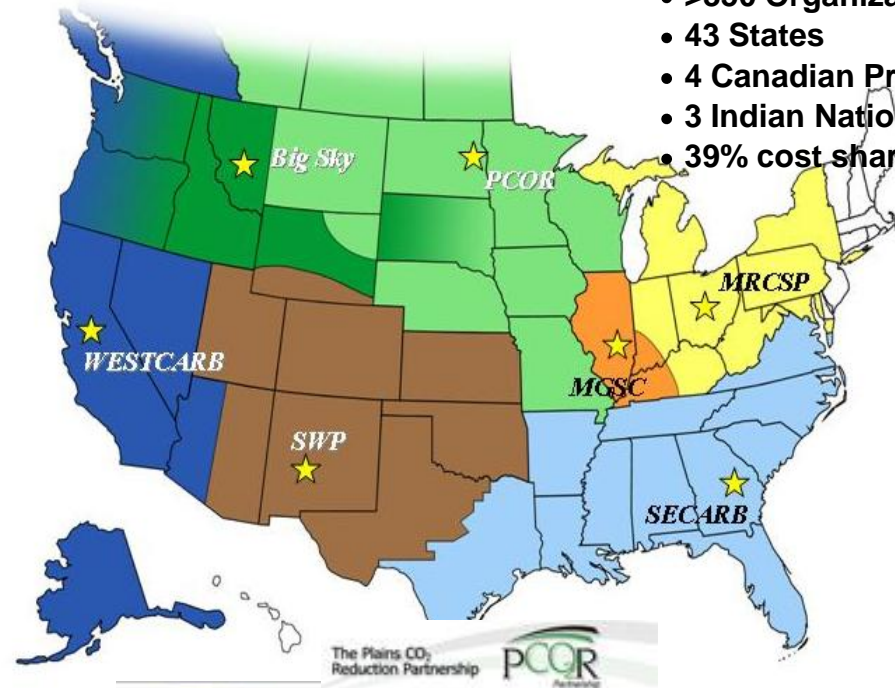
- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 25 Geologic field validation tests

## Deployment Phase

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

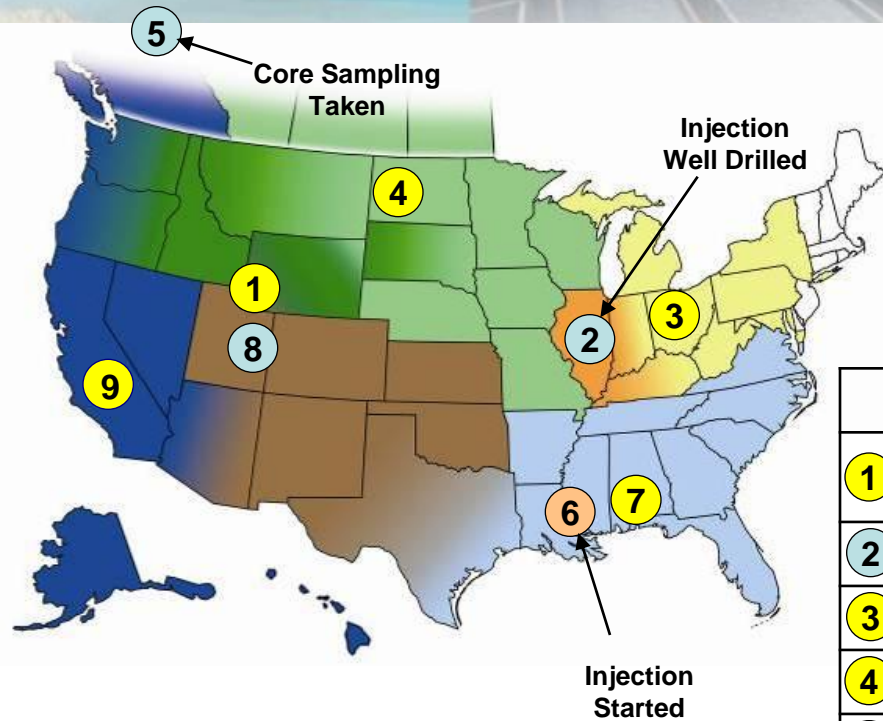
### Representing:

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



# RCSP Phase III: Development

## Large-Volume Geologic Field Tests



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

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

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

# RCSP - Phase III Projects



## Plains CO<sub>2</sub> 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<sub>2</sub> in deep carbonate/saline)
  - CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> from a natural CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> from Cimarex Energy's planned helium and natural gas processing plant
    - Total Project Cost: \$130.6M (DOE Share: 66.9M)

# DOE's Global CCS Demonstration Role on Six Continents

## Selected DOE Participation in International CO<sub>2</sub> Storage Projects

<i>Location</i>	<i>Operations</i>	<i>U.S. Invol.</i>	<i>Reservoir</i>	<i>Operator /Lead</i>	<i>Int'l Recognition</i>
North America, Canada Saskatchewan <b>Weyburn-Midale</b>	1.8 Mt CO <sub>2</sub> /yr commercial 2000	2000-2011	oil field carbonate EOR	Encana, Apache	IEA GHG R&D Programme, CSLF
North America, Canada, Alberta <b>Zama oil field</b>	250,000 tons CO <sub>2</sub> , 90,000 tons H <sub>2</sub> S demo	2005-2009	oil field carbonate EOR	Apache (Reg. Part.)	CSLF
North America, Canada, British Columbia <b>Fort Nelson</b>	> 1 Mt CO <sub>2</sub> /yr, 1.8 Mt acid gas/yr large-scale demo	2009-2015	saline formation	Spectra Energy (Reg. Part.)	CSLF
Europe, North Sea, Norway <b>Sleipner</b>	1 Mt CO <sub>2</sub> /yr commercial 1996	2002-2011	marine sandstone	StatoilHydro	IEA GHG R&D Programme, CSLF, European Com.
Europe, Germany <b>CO2SINK, Ketzin</b>	60,000-90,000 tonnes CO <sub>2</sub> demo 2008	2007-2010	saline sandstone	GeoForsch- ungsZentrum, Potsdam(GFZ)	CSLF, European Commission, IEA GHG R&D Prog
Australia, Victoria <b>Otway Basin</b>	100,000 tonnes CO <sub>2</sub> demo 2008	2005-2010	gas field sandstone	CO2CRC	CSLF
Africa, Algeria <b>In Salah gas</b>	1 Mt CO <sub>2</sub> /yr commercial 2004	2005-2010	gas field sandstone	BP, Sonatrach, StatoilHydro	CSLF, European Commission
Asia, China, <b>Ordos Basin</b>	assessment phase CCS	2008-TBD	Ordos Basin	Shenhua Coal	



# 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, CCPI, ICCS)
- **DOE greatly appreciates our continued excellent working relationship with NARUC and the various State regulators**