The Roadmap for Carbon Capture and Sequestration

CCS Forum

University of Charleston

Charleston, West Virginia

8 September, 2010

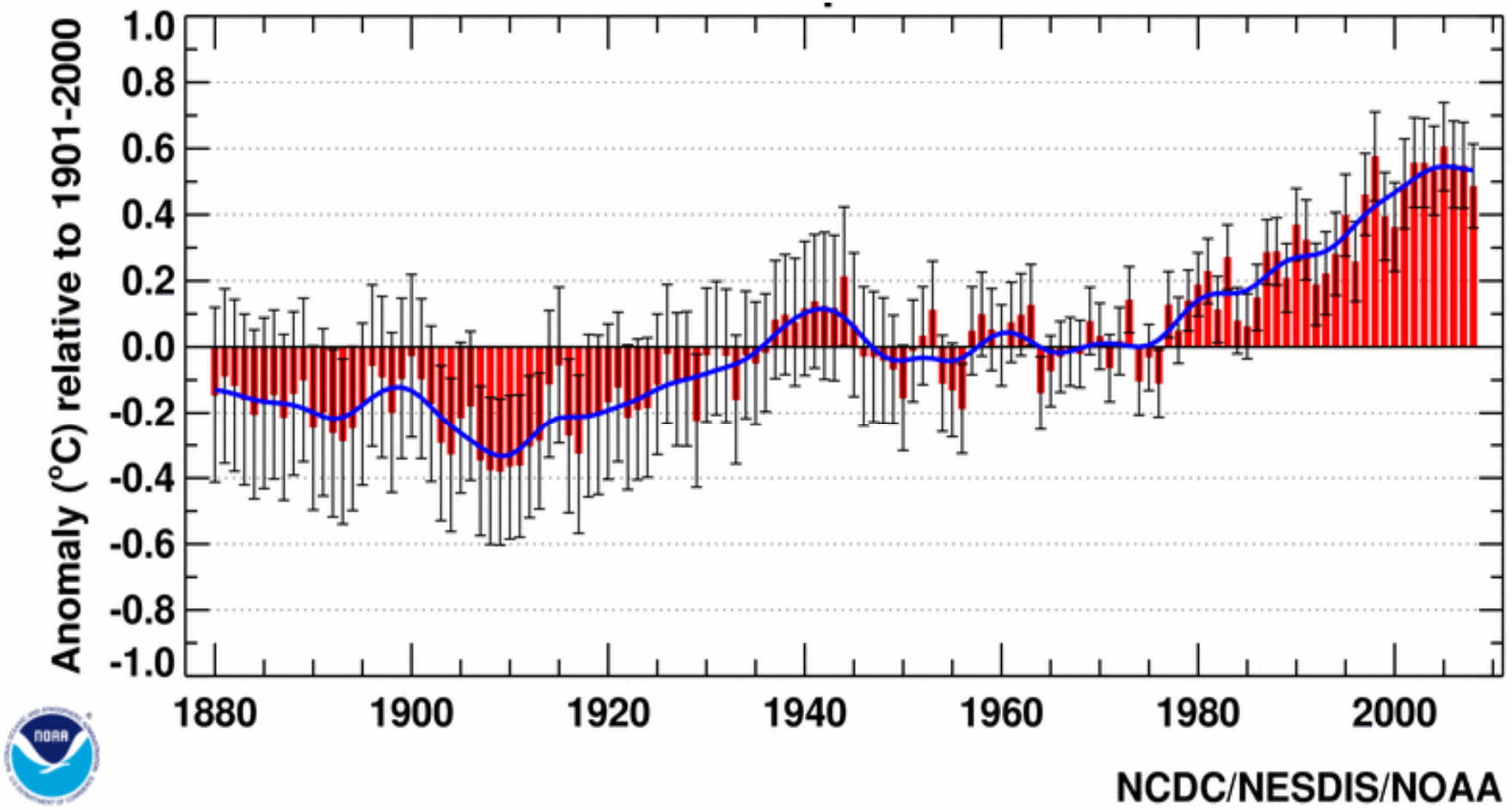
America has abundant coal resources

Coal will continue to be an important part of America's and the world's energy supplies

The Obama Administration is committed to a clean future for coal

Our challenge is to lead the world on carbon capture and sequestration

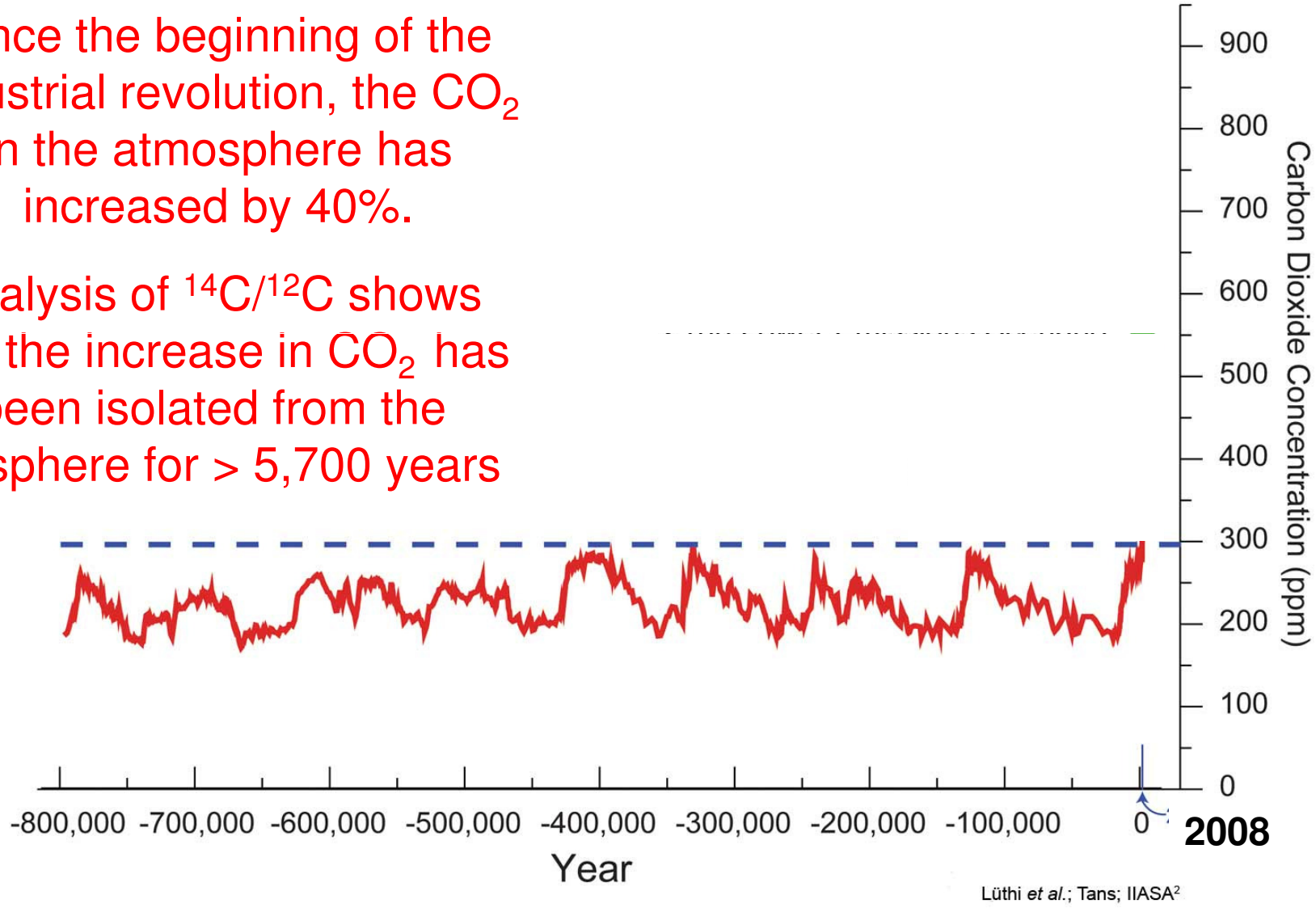
Temperature Record (1880 – 2008)



Carbon Dioxide Concentration during the past 800,000 years

Since the beginning of the industrial revolution, the CO_2 in the atmosphere has increased by 40%.

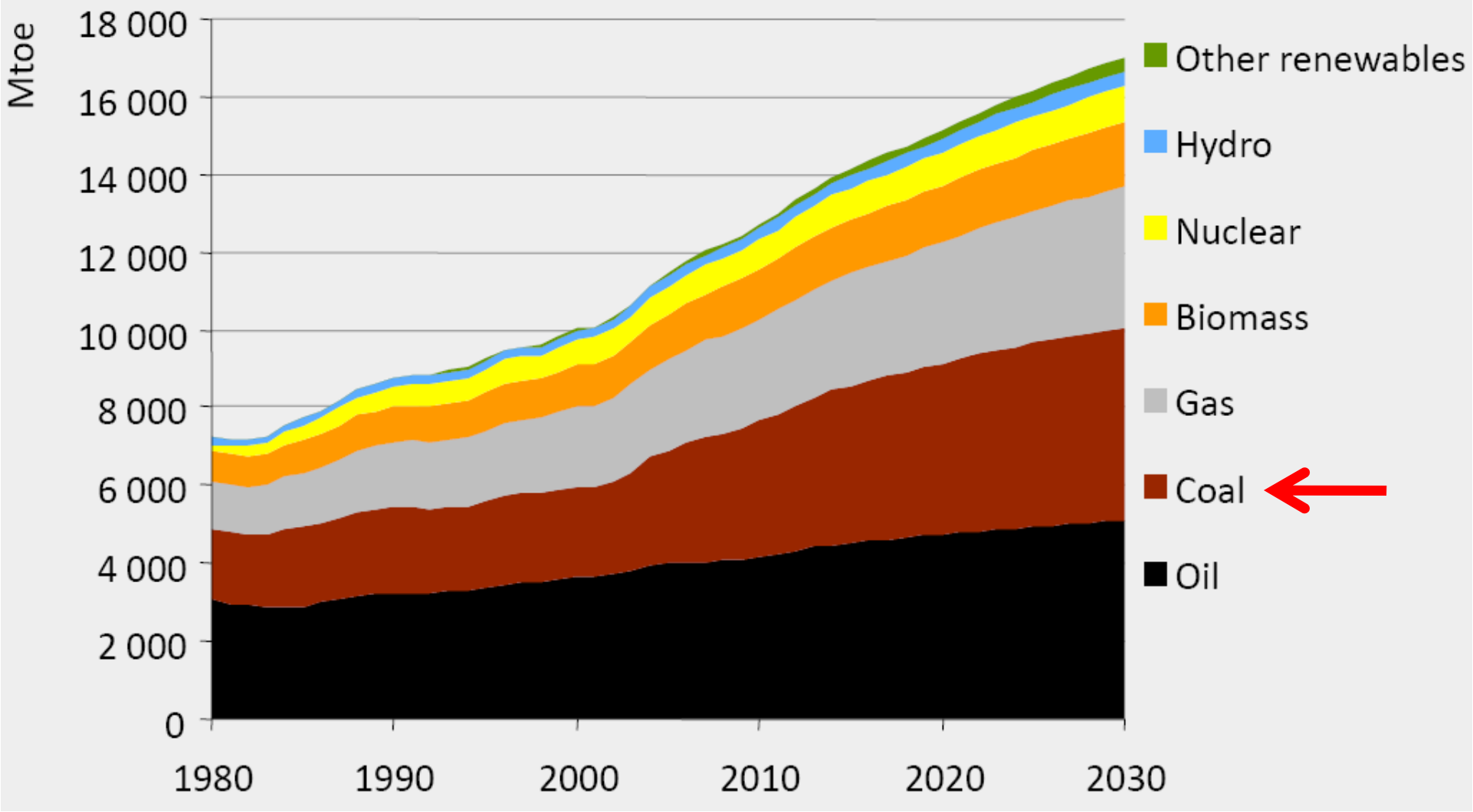
Analysis of $^{14}C/^{12}C$ shows that the increase in CO_2 has been isolated from the biosphere for > 5,700 years



The US, China, Russia, Australia, and India have ¾ of the world's known coal reserves.

It is highly unlikely any of these countries will turn its back on coal any time soon

IEA: Coal will supply more than 1/3 of projected increase in world energy demand



IEA

The Obama Administration has a comprehensive strategy to advance CCS

We're making an historic investment in CCS – including $3.4 billion from the Recovery Act

The President created the **Interagency Task Force on Carbon Capture and Storage**

Our goal is to begin commercial deployment of CCS in 8 – 10 years

To achieve our CCS goals, we are:

- Demonstrating and deploying 1st generation technologies

We're funding a variety of apporaches

Pre-combustion

Removal of carbon dioxide during gasification (IGCC)

Sorbents

Post-Combustion

Amine and chilled ammonia capture

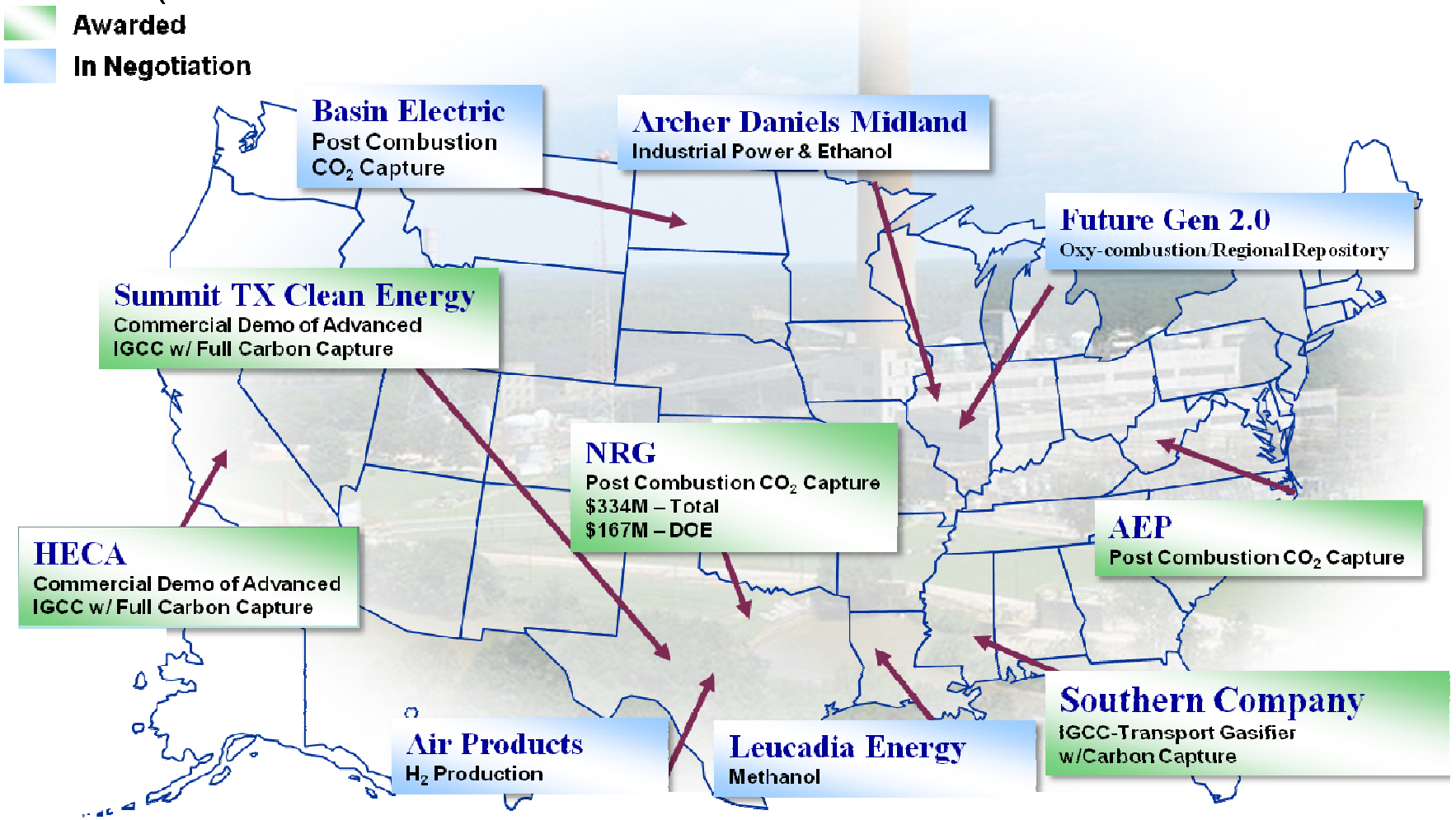
Oxycombustion

Separation oxygen from air and burning in an O_2 + CO_2 mixture

Oxycombustion

The Recovery Act is funding:

- 3 commercial-scale IGCC + CCS plants
- 3 industrial-scale CCS applications
- 1 commercial-scale Oxycombustion + CCS retrofit (FutureGen 2.0)



West Virginia CCS projects

AEP's Mountaineer Carbon Capture and Geologic Storage Demonstration Project

$334 million project
near New Haven, WV

Chilled ammonia process,
90% capture of CO_2,
permanent saline storage

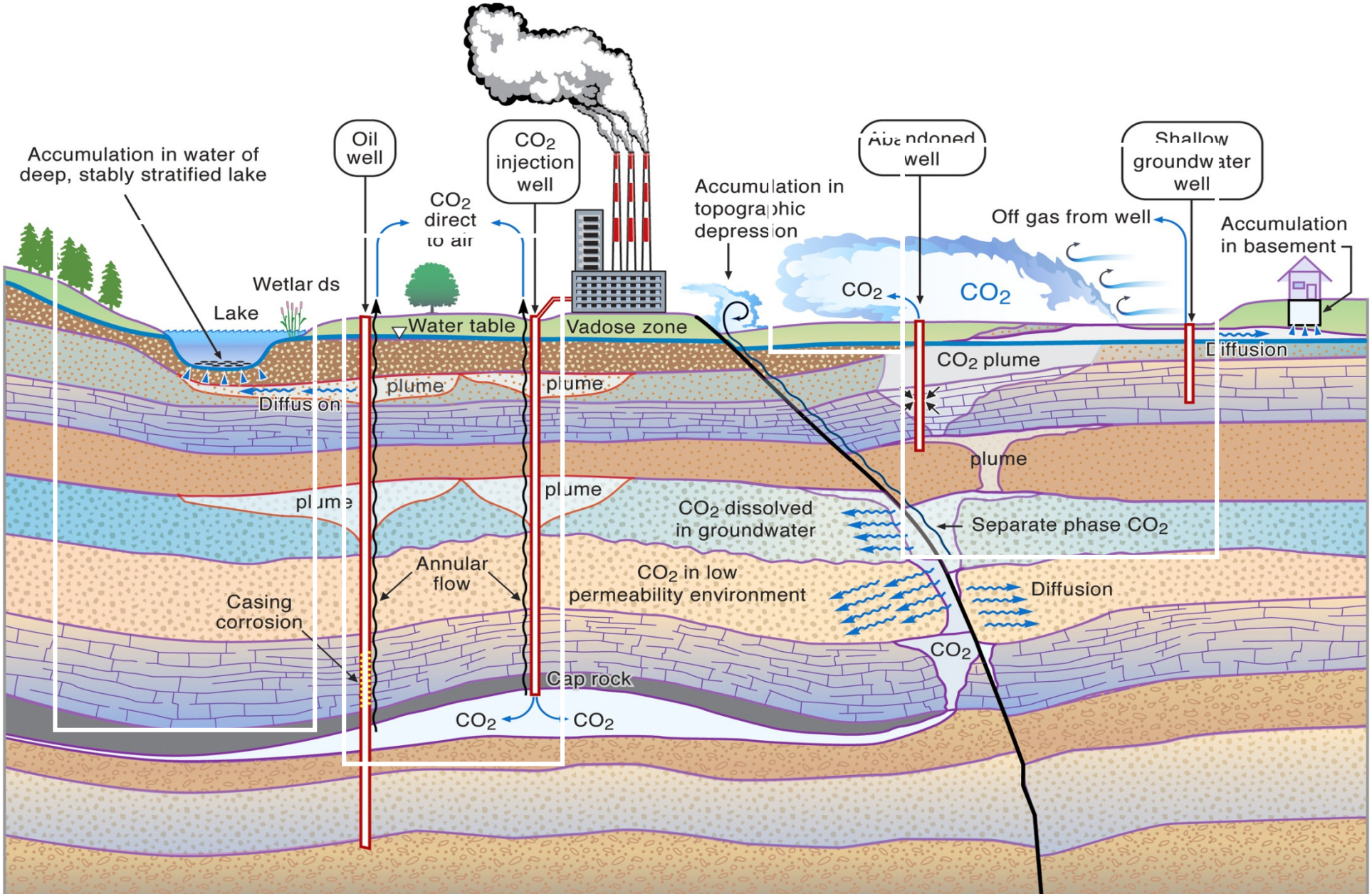
More than $20 million in projects for:

- Sequestration in unminable coal seams
- CO_2 reuse for algae production
- Reservoir assessment software
- Coal liquefaction

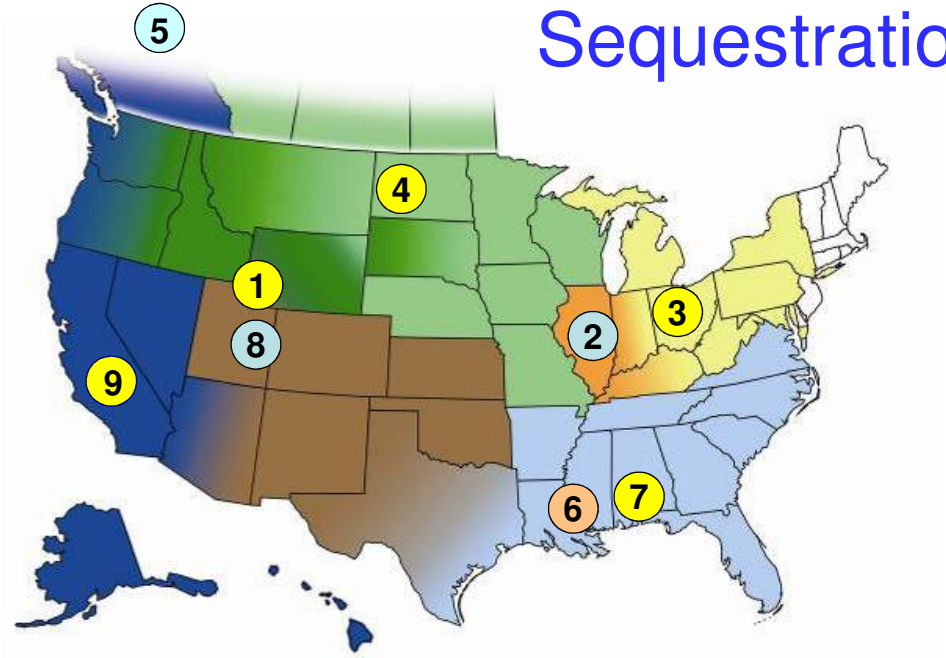
To achieve our CCS goals, we are:

- Demonstrating and deploying 1st generation technologies
- Advancing our understanding of geologic sites

Long term geological storage in a variety of aquifers will be tested by the DOE in a variety of sites.



Regional Carbon Sequestration Partnerships



- ***Nine large-volume tests***

2009 Injection Scheduled
2010 Injection Scheduled
2011 Injection Scheduled

RECOVERY.GOV

The Recovery Act included $50 million for geologic site characterization

To achieve our CCS goals, we are:

- Demonstrating and deploying 1st generation technologies
- Advancing our understanding of geologic sites
- Pursuing international collaborations

Last week, we announced that West Virginia University will lead a new **U.S. – China Clean Energy Research Center** on CCS

The recent Clean Energy Ministerial established the **Carbon Capture Use and Storage Action Group**

CLEAN ENERGY MINISTERIAL

carbon sequestration leadership forum

The CSLF will add four projects and welcome the UAE as its 25th member at the 2010 annual meeting

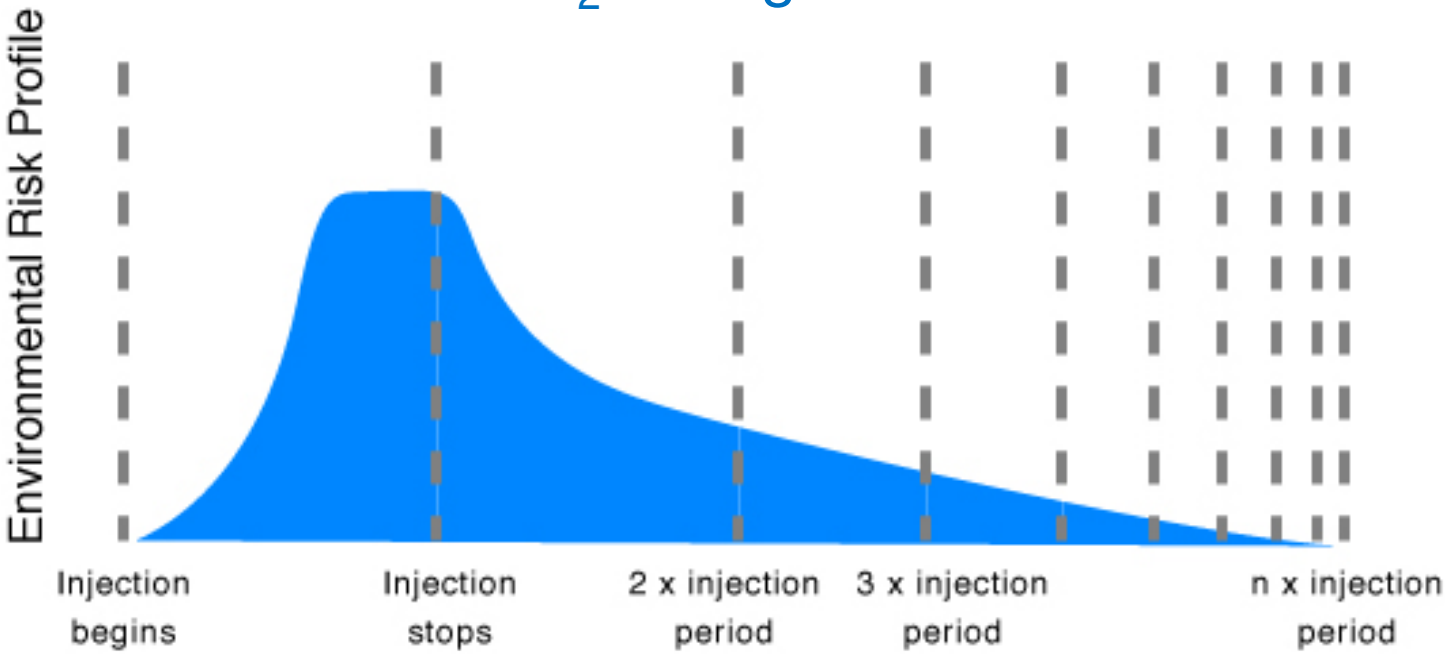
To achieve our CCS goals, we are:

- Demonstrating and deploying 1st generation technologies
- Advancing our understanding of geologic sites
- Pursuing international collaborations
- Addressing barriers to CCS deployment

Concerns for CCS deployment include:

- **Market failures**, especially the lack of a price on carbon
- Need for a **legal/regulatory framework**
- Clarity with respect to **long-term liability**
- Need for **public information, education, and outreach**

For example, explaining to the public that the risks of CO_2 storage decline over time



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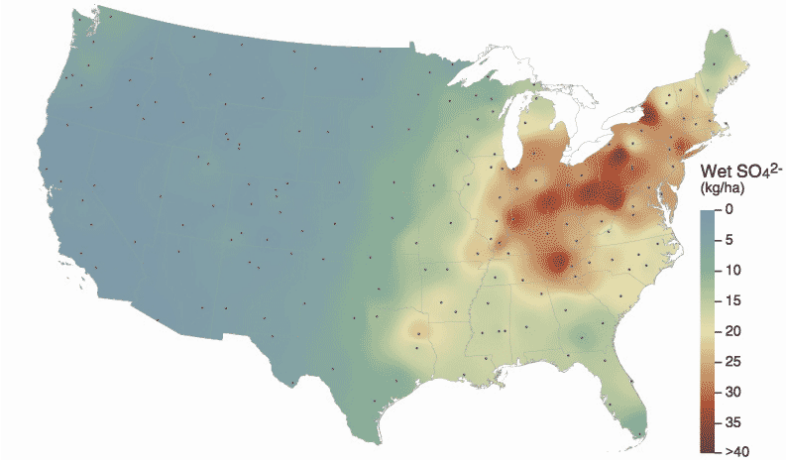
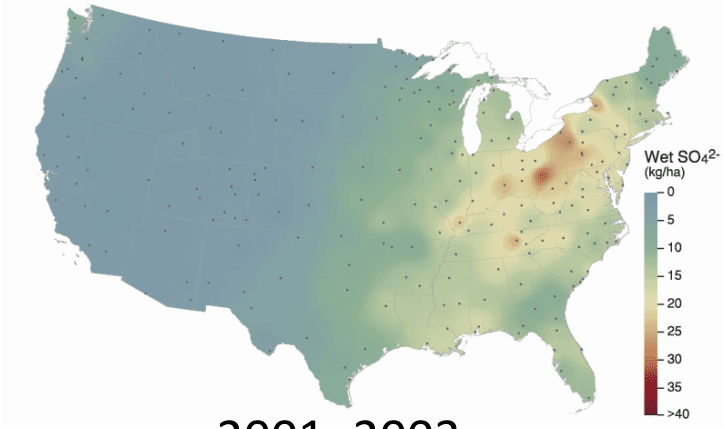
- Demonstrating and deploying 1st generation technologies
- Advancing our understanding of geologic sites
- Pursuing international collaborations
- Addressing barriers to CCS deployment
- Accelerating next generation technologies

The cost of the Acid Rain Program



Annual Mean Wet Sulfate Deposition
1989 - 1991

Did the Clean Air act work and how much did it cost?



2001 -2003

(source: EPA; Center for American Progress)

- Electric utilities estimated an $8.5 billion/year cost if the 1990 Clean Air Act were to pass
- The Bush ('41) Administration's estimate was $7 billion a year
- **The actual cost was $2.3 billion a year – about one-third the estimates**

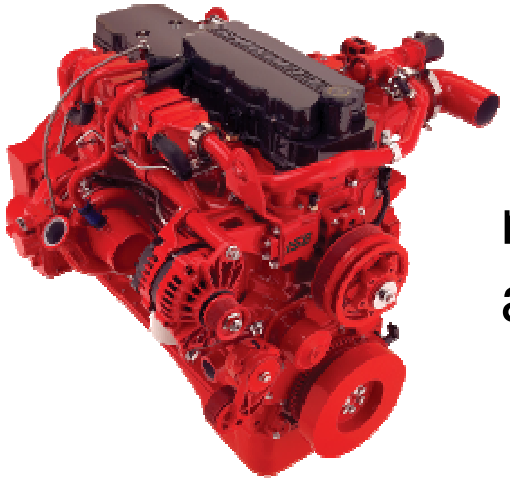
- EPA estimate: each allowance per ton of sulfur would cost $750 during the first phase
- The actual price per ton began at $250-$300 in 1992, and eventually fell to **$70 in 1996 – one-tenth of the predicted cost!**

We're accelerating 2nd generation CCS R&D

Advanced CO2 Capture	Advanced Solid Sorbent Oxy-combustion Gas Flow Membrane Oxygen Transport Membrane Solvent-based POSTCAP CO_2 Process
Turbo Machinery	Industrial-frame Turbine Components Advanced Hydrogen-fueled Gas Turbine Oxy-fuel Turbine Supersonic Compression
Large-Scale Testing	Non-cryogenic Air Separation Hydrogen Transport Membrane Warm Gas Cleanup

U.S. DEPARTMENT OF ENERGY

Computer simulation can speed technology development

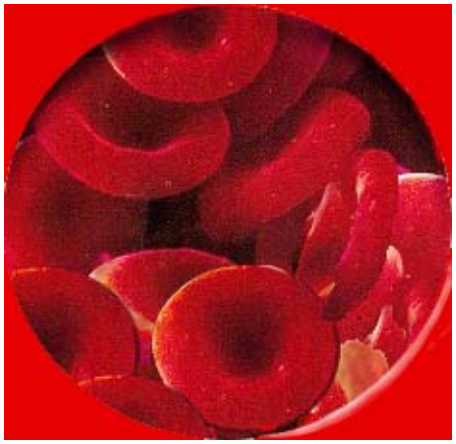


For example, in partnership with DOE's national labs, Cummins developed the first all-computationally-designed diesel engine

Today, we're announcing up to $40 million from the Recovery Act for the creation of the **Carbon Capture and Storage Simulation Initiative**

NETL will be the lead laboratory

Nature has found a way to capture, transport and release CO_2 without using excess energy.



A synthetic analogue of an enzyme used by red blood cells to capture CO_2 in the human body

The DOE is sponsoring research that seeks to produce Nature-inspired catalysts that can survive in a flue-gas environment.

We are also funding research in radically new membrane technologies that will separate

1) Oxygen from air for oxy-combustion

2) CO_2 from N_2, O_2, H_2O for conventional coal and gas plants.

The momentum of the Recovery Act needs to be sustained

Industry and government must work together to accelerate innovation

The United States must remain the world leader on CCS – to ensure a clean future for coal and drive our future prosperity