Clean Coal Technology Options

Clean Coal Symposium

January 25, 2006

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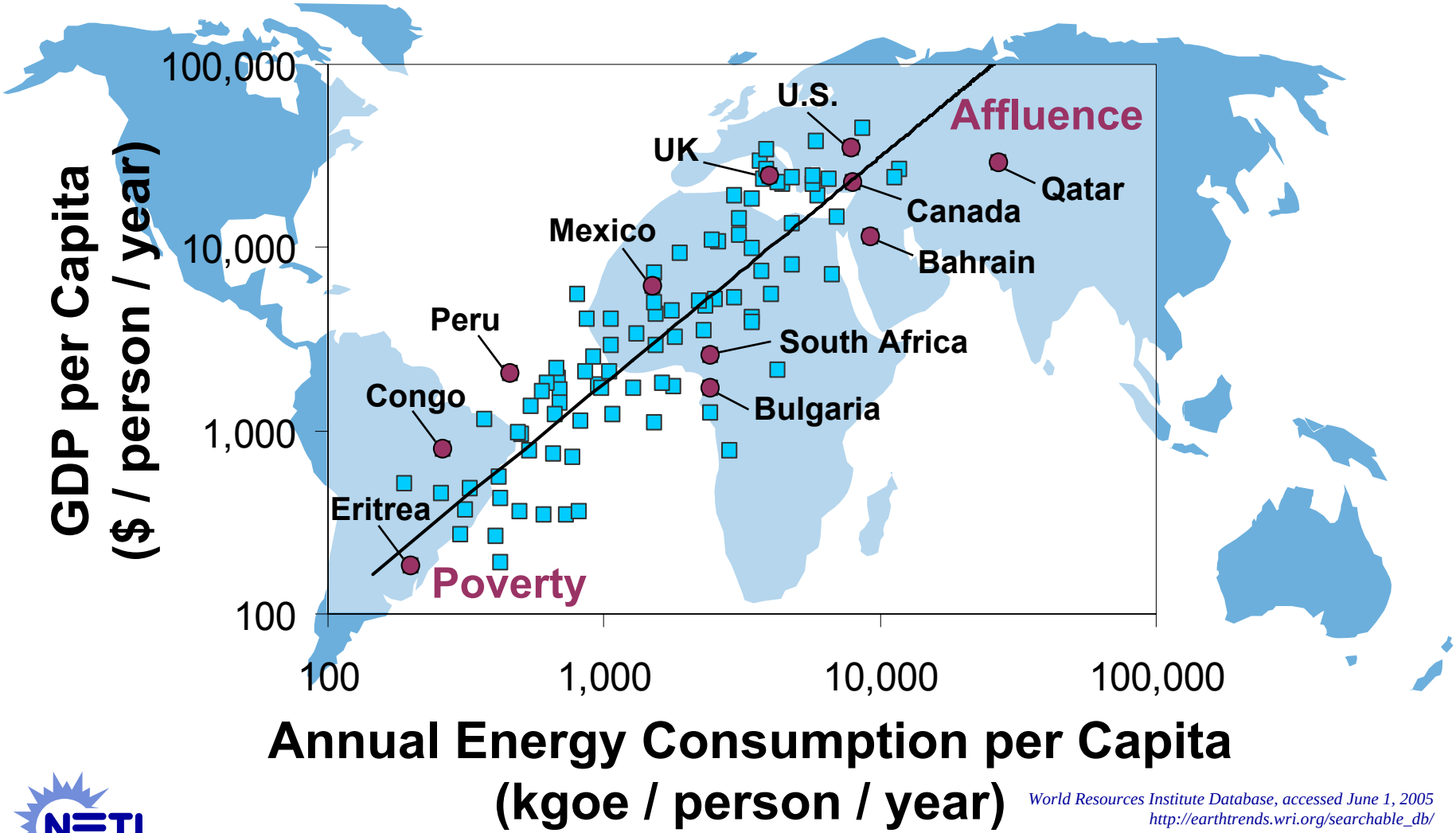
National Energy Technology Laboratory

U.S. Department of Energy, Office of Fossil Energy

Energy = Quality of Life



World Resources Institute Database, accessed June 1, 2005
http://earthtrends.wri.org/searchable_db/

U.S. DOE Coal & Power Program

Core R&D Program

- Innovations for existing plants
- FutureGen support

Presidential Initiatives / Drivers

- Clear Skies
- Global Climate Change
- Hydrogen Fuels
- FutureGen

FutureGen

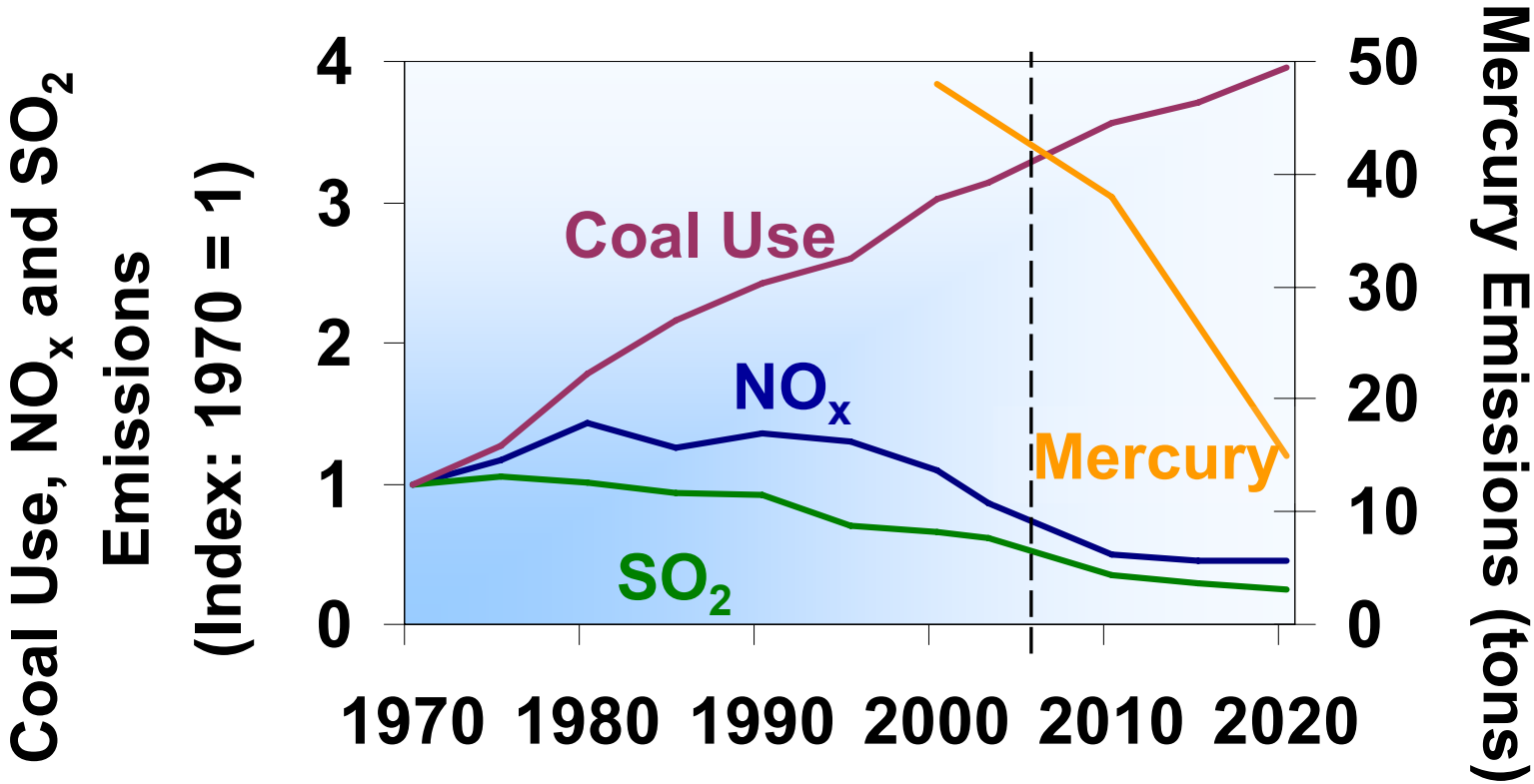
- Integrated sequestration, hydrogen, and power research facility

Demonstration Program

- Clean Coal Power Initiative
- Power Plant Improvement Initiative
- Clean Coal Technology program

Air Emission Trends and Projections

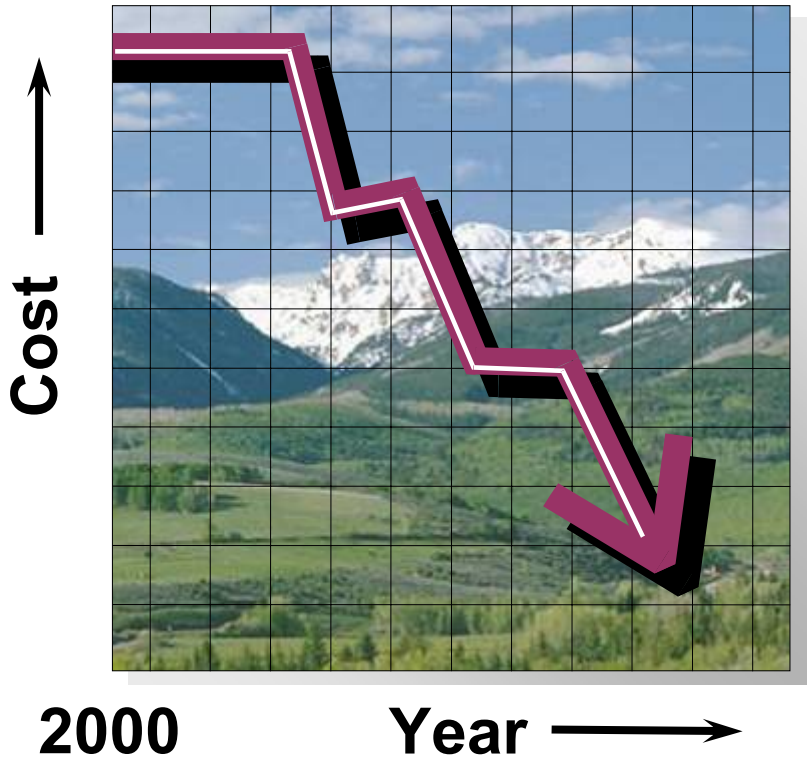
Annual U.S. Air Emissions and Coal Use



Historical data (1970–2000): Coal consumption and electricity generation per DOE EIA, AER 2003
NO_x and SO_2 per EPA Air Trends Report: http://www.epa.gov/air/airtrenda/econ-emissions.html
Projected data (2003–2020): Coal consumption and electricity generation per DOE EIA, AEO 2005
NO_x and SO_2 per EPA projections under CAIR: http://www.epa.gov/interstateairquality/charts.html
Mercury per EPA Clean Air Mercury Rule

U.S. DOE Mercury Control RD&D

- **Commercial demo targets**
  - 2007 → reduce by 50–70%
  - 2010 → reduce by ≥ 90%
- **Reduce cost by 25–50%**

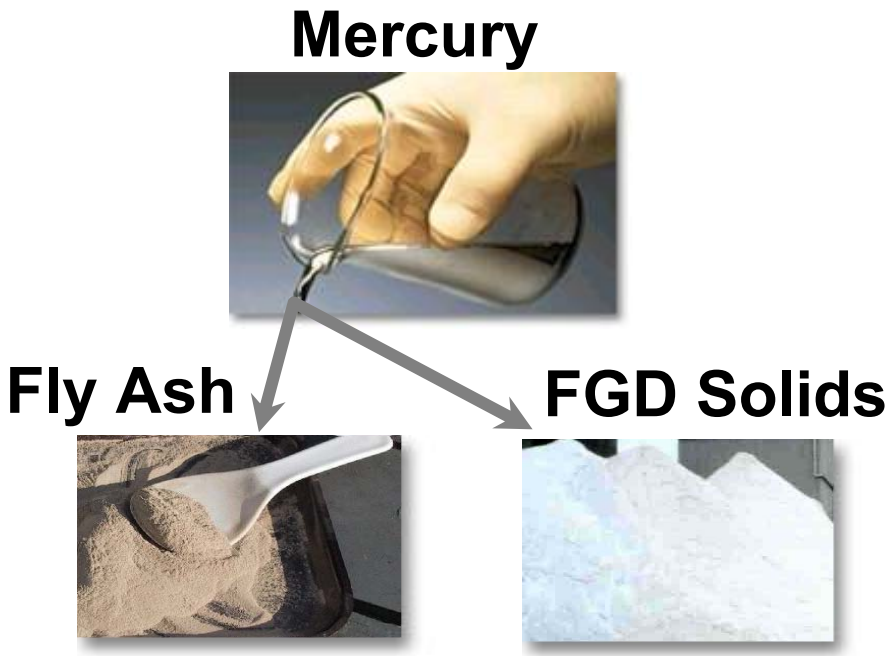


Baseline (1999) Costs: ~ $50,000 – 70,000 / lb Hg Removed

World Resources Institute Database, accessed June 1, 2005
http://earthtrends.wri.org/searchable_db/

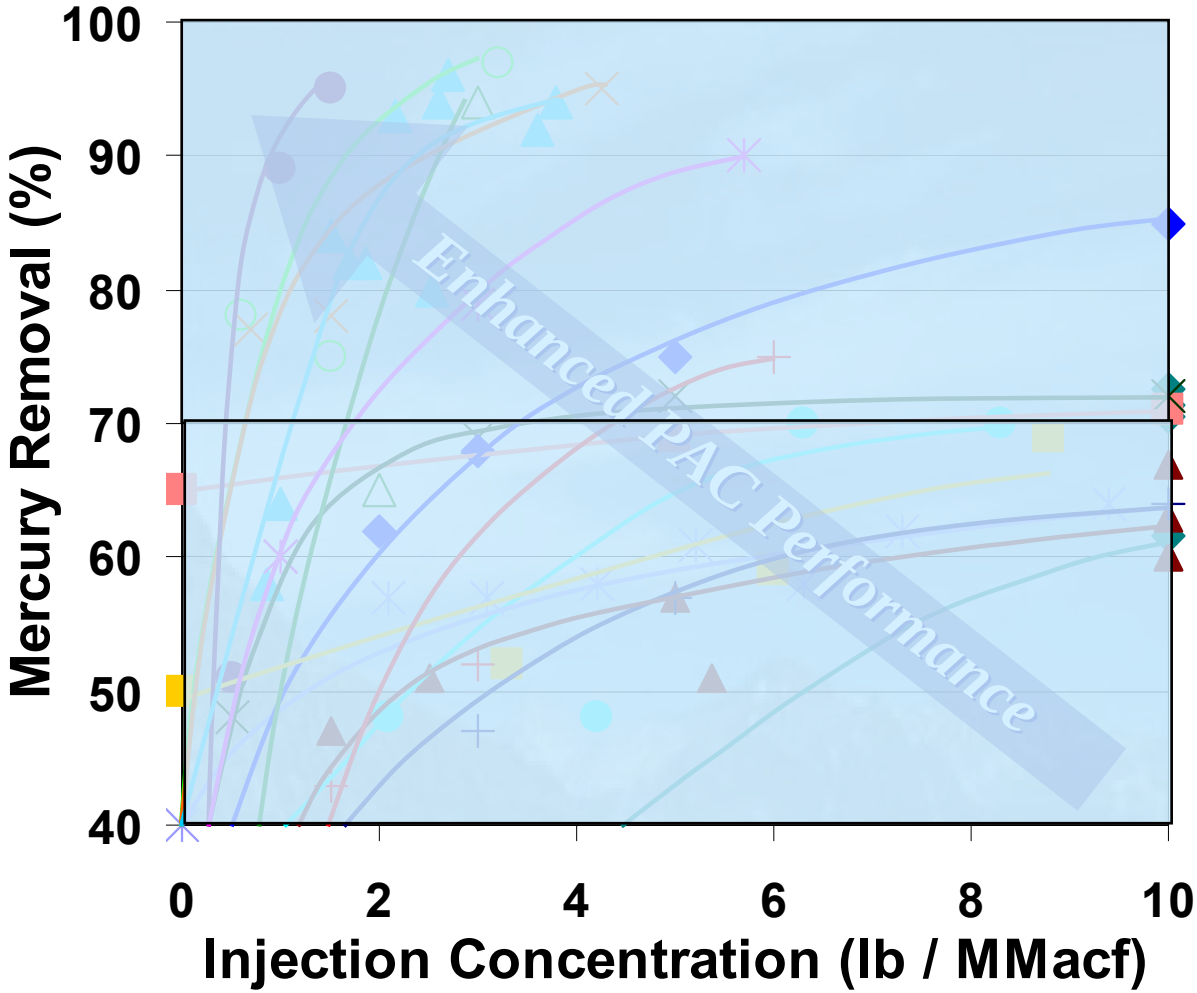
U.S. DOE Mercury Control RD&D

- **Bench-scale demos**
  - Co-benefit control
    - SCR
    - FGD
  - Sorbent injection
    - Activated carbon
  - Hg oxidation systems
    - Catalysts
    - Chemical additives
- **Byproduct characterization for Hg**

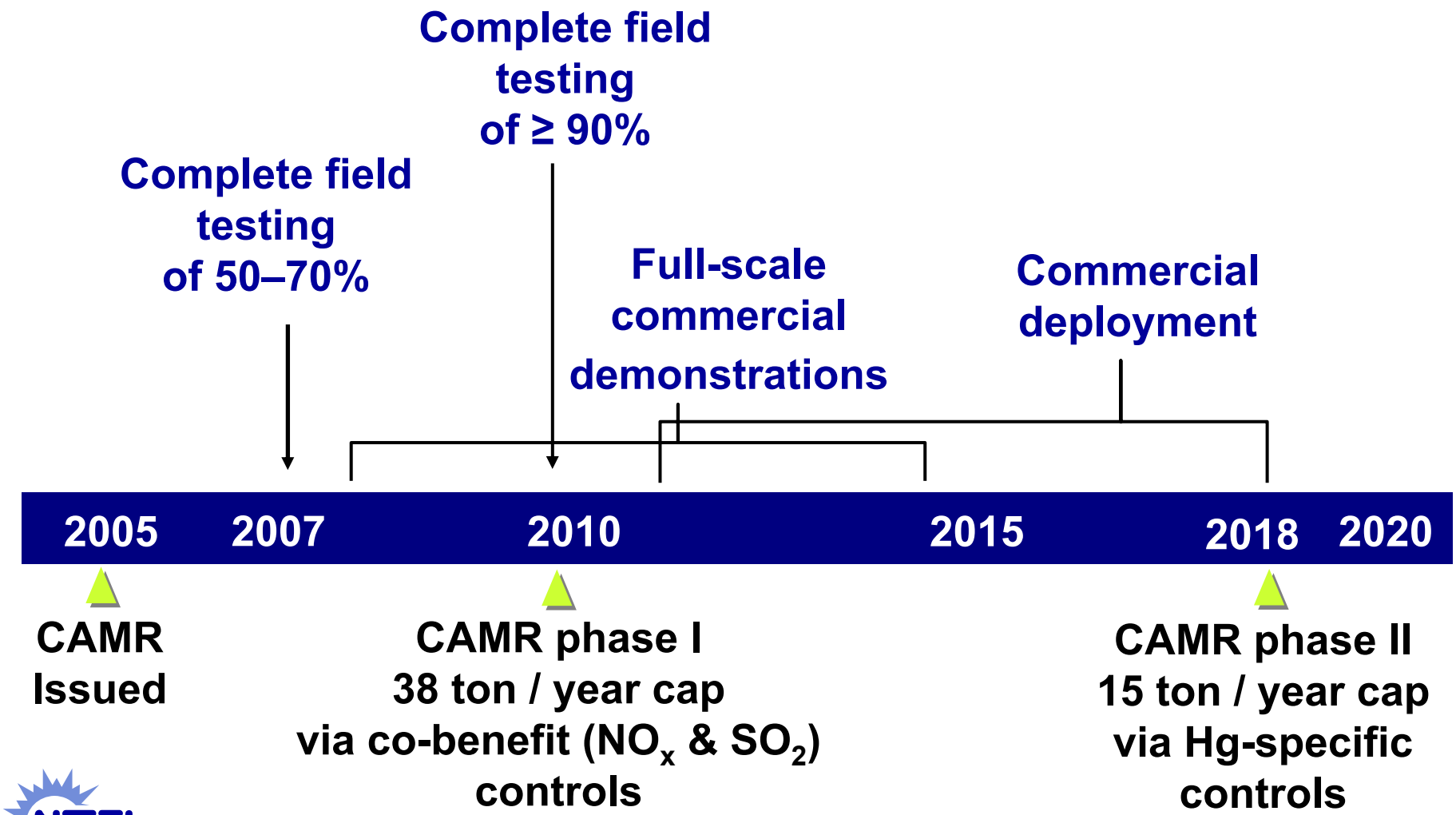


U.S. DOE Mercury Control RD&D

Activitated Carbon Injection Field Testing



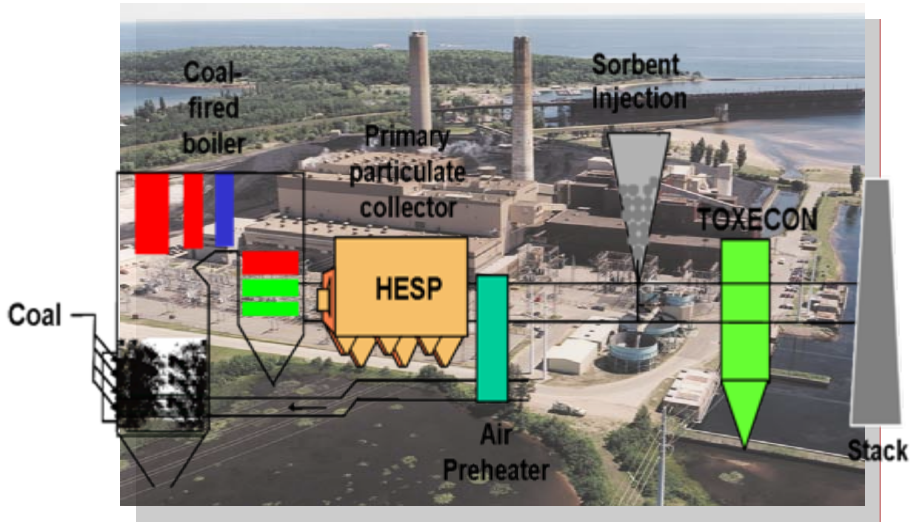
U.S. DOE Mercury Control RD&D



U.S. DOE Mercury Control RD&D

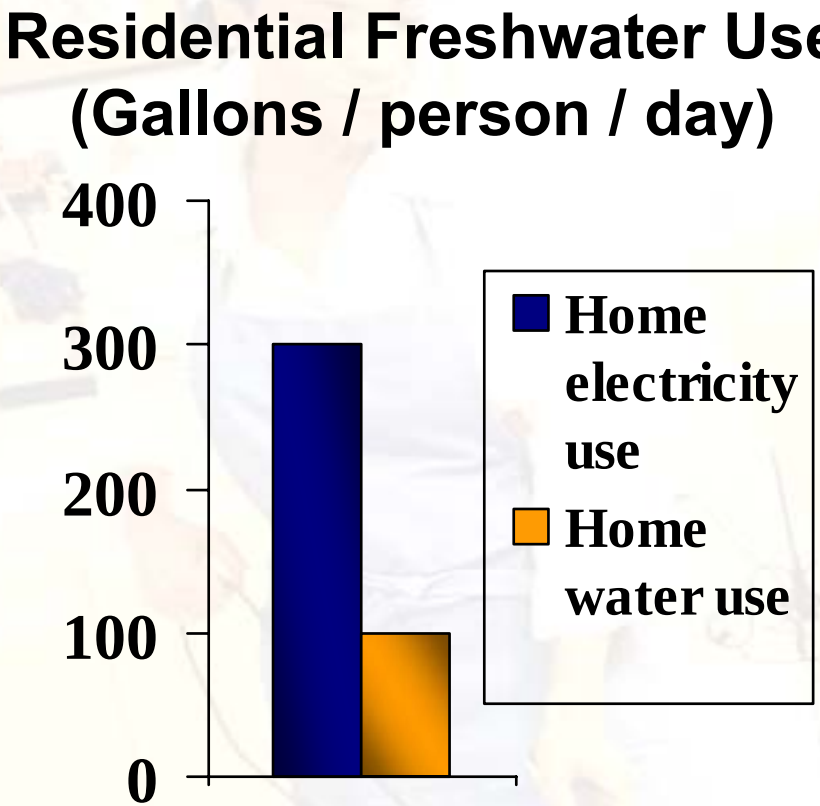
TOXECON™ Retrofit Mercury / Multi-Pollutant Control

- **270-MW**
- **Goals**
  - 90% Hg
  - 70% SO_2
  - 30% NO_x
- **CCPI Project**
  - $53.3M total
  - $24.9M DOE
  - $28.5M We Energies



Presque Isle Power Plant
Marquette, Michigan

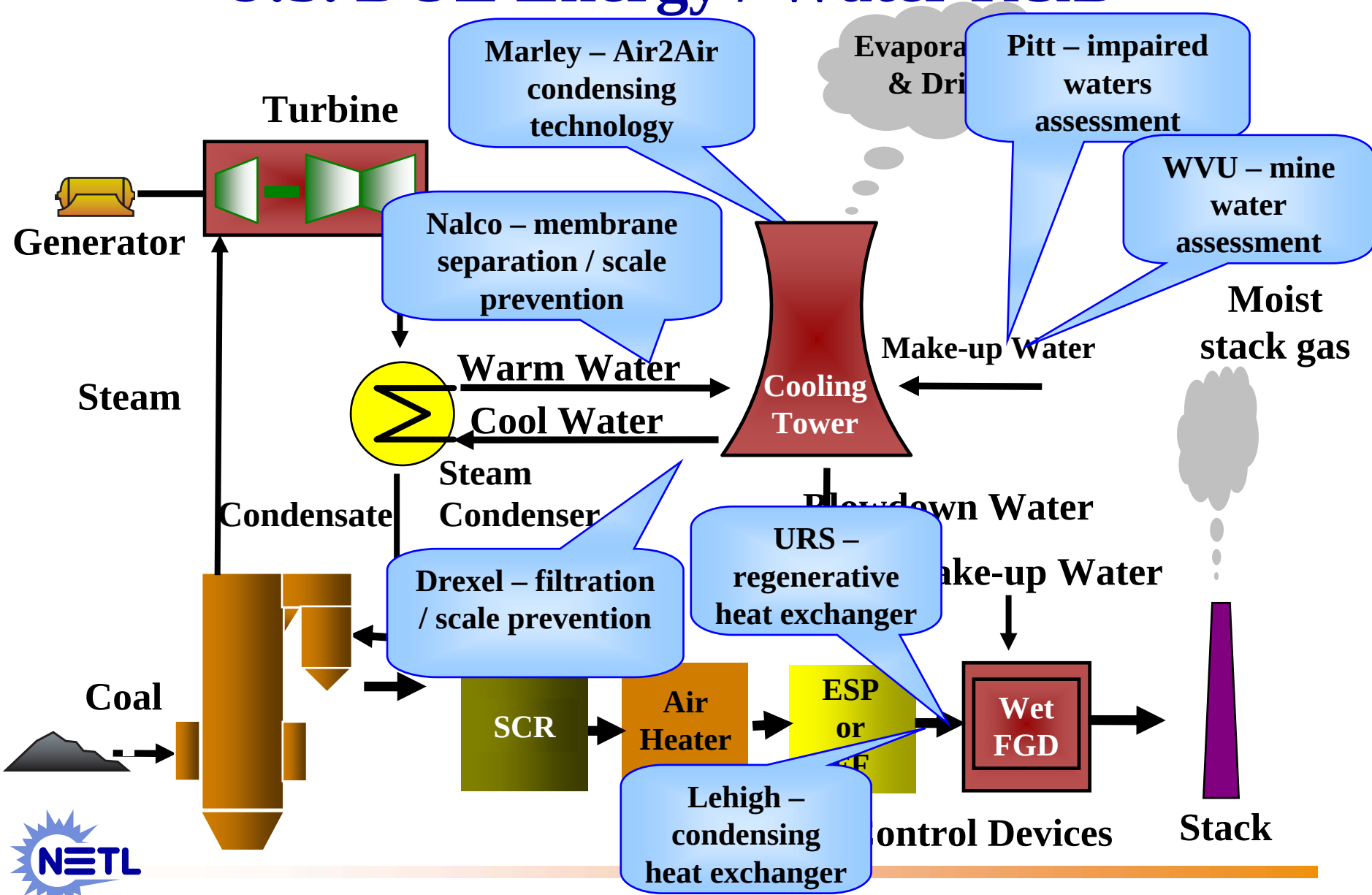
Water and Electricity Inextricably Linked



- Each kilowatt hour of electricity 25 gallons
- Use 3 times as much water turning on lights as taking showers

DOE / NETL Draft Final Report, "Water-Energy RD&D Scoping Report, September 2003"

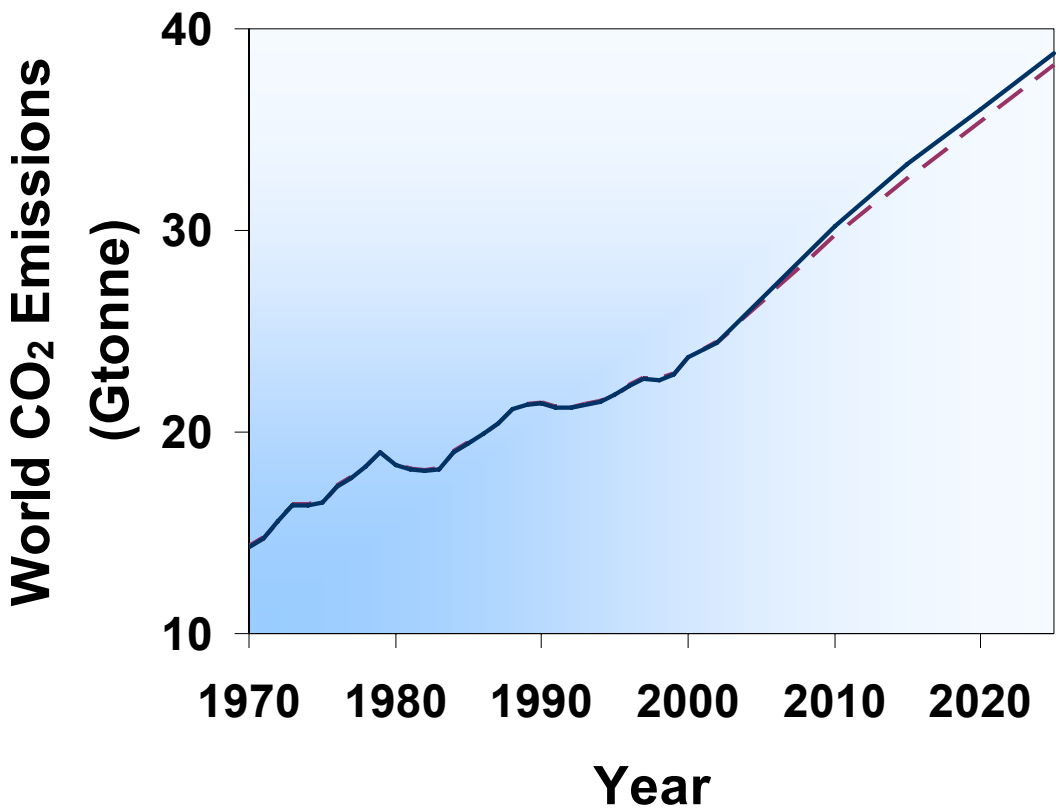
U.S. DOE Energy / Water R&D



"When the well runs dry we know the worth of water."

– Benjamin Franklin

World CO_2 Emissions Growing Dramatically



Reference Case

Kyoto Protocol Case

Upper: DOE EIA, International Energy Outlook 2005, Figures 5–6
Lower: DOE EIA, International Energy Outlook 2005, Tables A11–A13

Carbon Sequestration Program Structure

Core R&D

Capture of CO_2

Monitoring, Mitigation, & Verification

Sequestration
- Direct CO_2 storage
- Enhanced natural sinks

Non-CO_2 GHG Mitigation

Break-through Concepts

Carbon Sequestration Leadership Forum

Infrastructure

7 Regional Partnerships

- Engage regional, state, local governments
- Determine regional seq. benefits
- Baseline region for sources & sinks
- Establish monitoring & verification protocols
- Address regulatory, environmental, & outreach issues
- Validate seq. technology and infrastructure

Initiated FY 2003

Integration

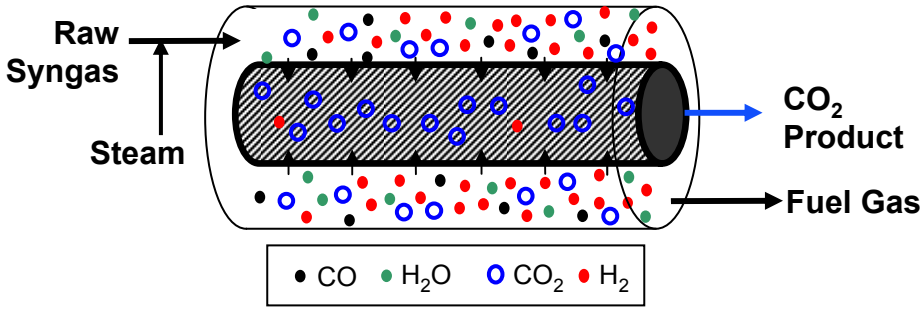
Power / Sequestration Complex

- First-of-kind integrated project
- Verify large-scale operation
- Highlight best technology options
- Verify performance & permanence
- Develop accurate cost & performance data
- International showcase

Initiated FY 2004

Carbon Sequestration Program

$$CO + H_2O \Longleftrightarrow CO_2 + H_2$$



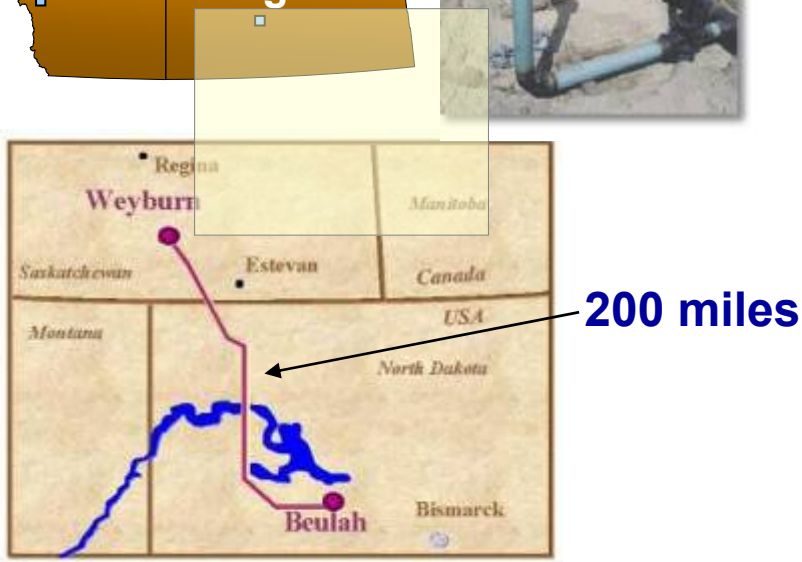
Hydrotalcite / Ceramic Membrane for Selective CO_2 Removal

- **Concentrated**
  - CO_2
  - H_2
- **< $**

Participants: Media and Process Technology & University of Southern California

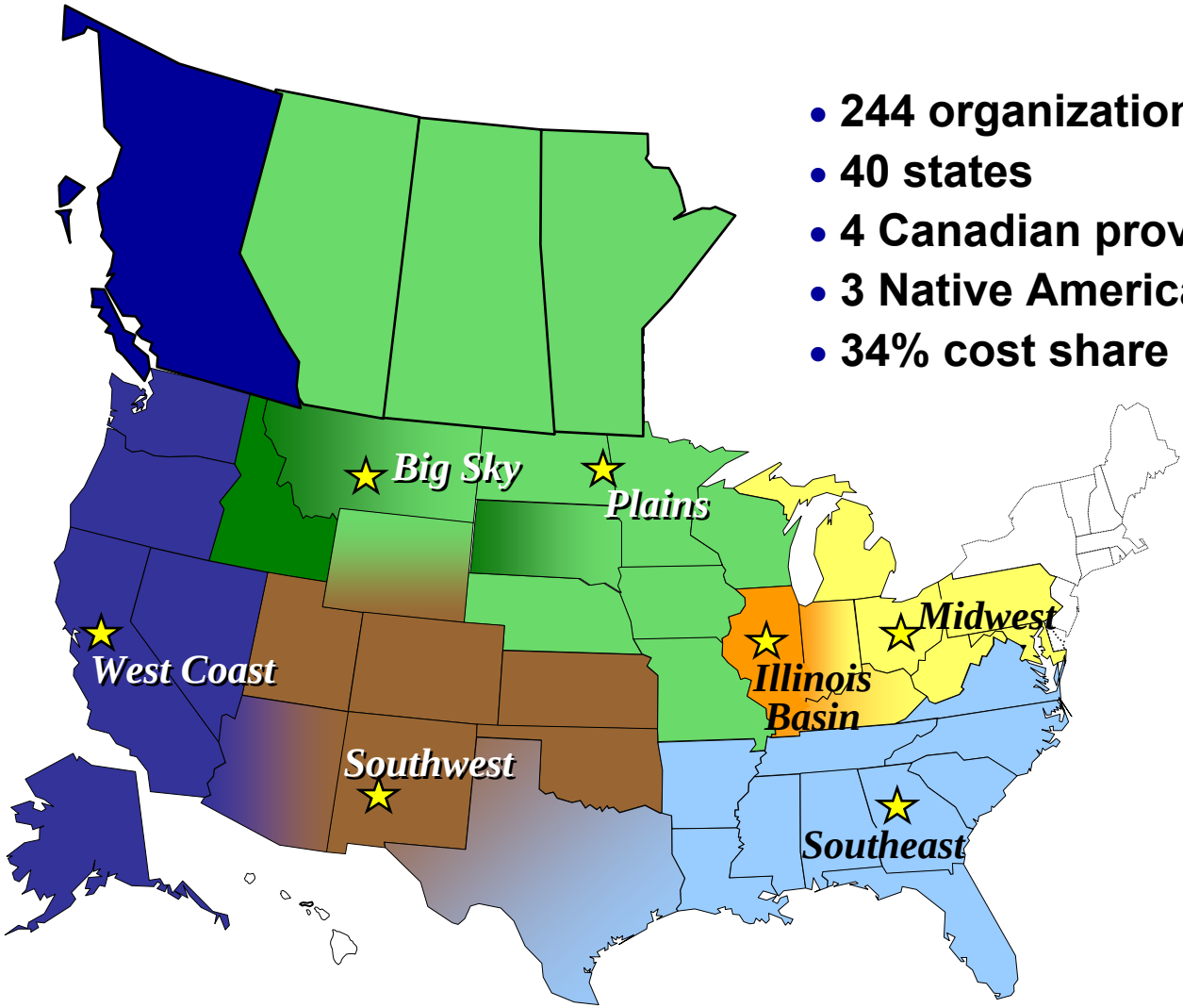
Carbon Sequestration Program

Weyburn EOR Project



- Fate of CO_2
- 8-year monitoring period
- 1M tons
- ~ 150-MW

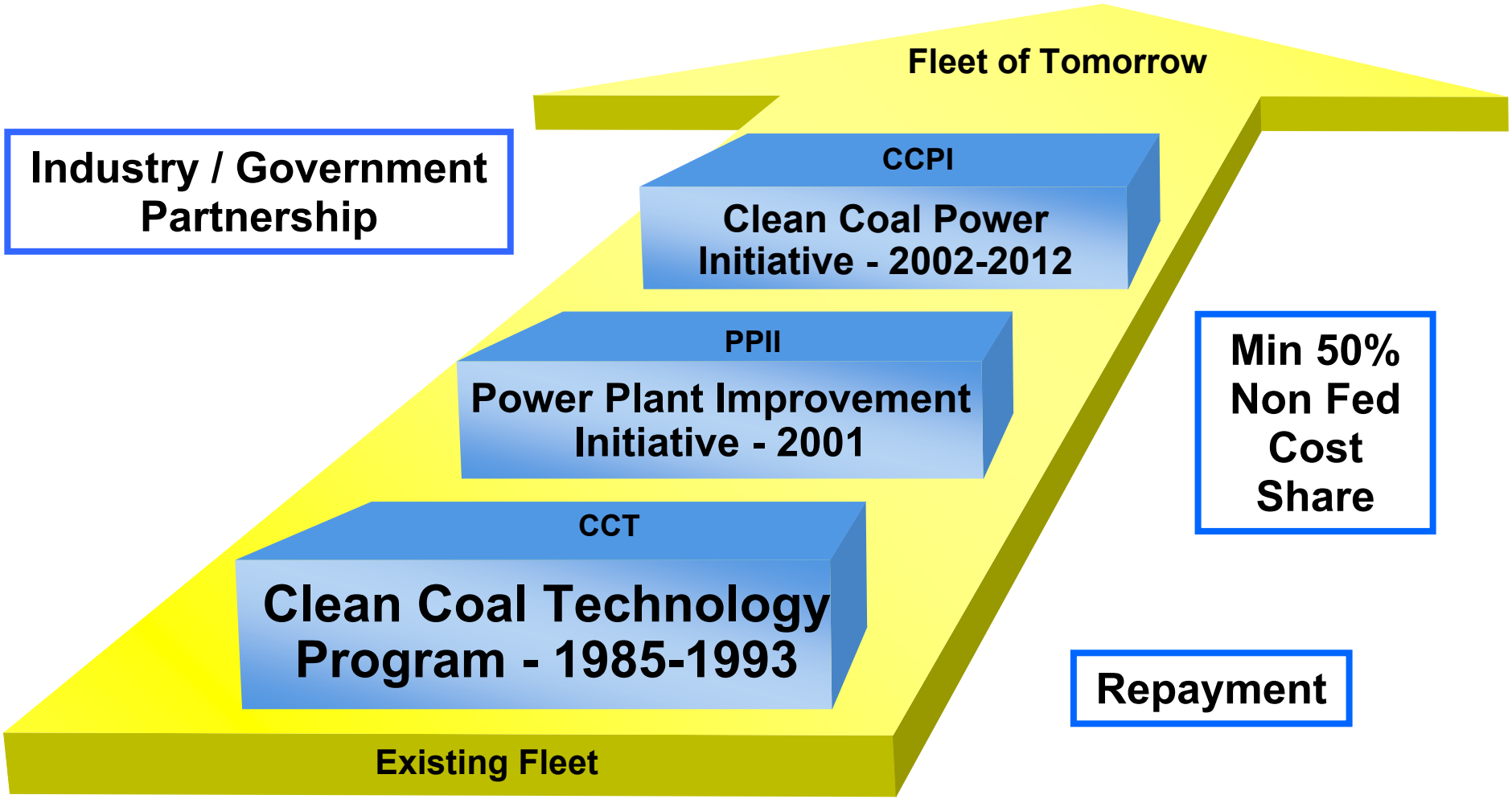
Regional Carbon Sequestration Partnerships



- 244 organizations
- 40 states
- 4 Canadian provinces
- 3 Native American
- 34% cost share

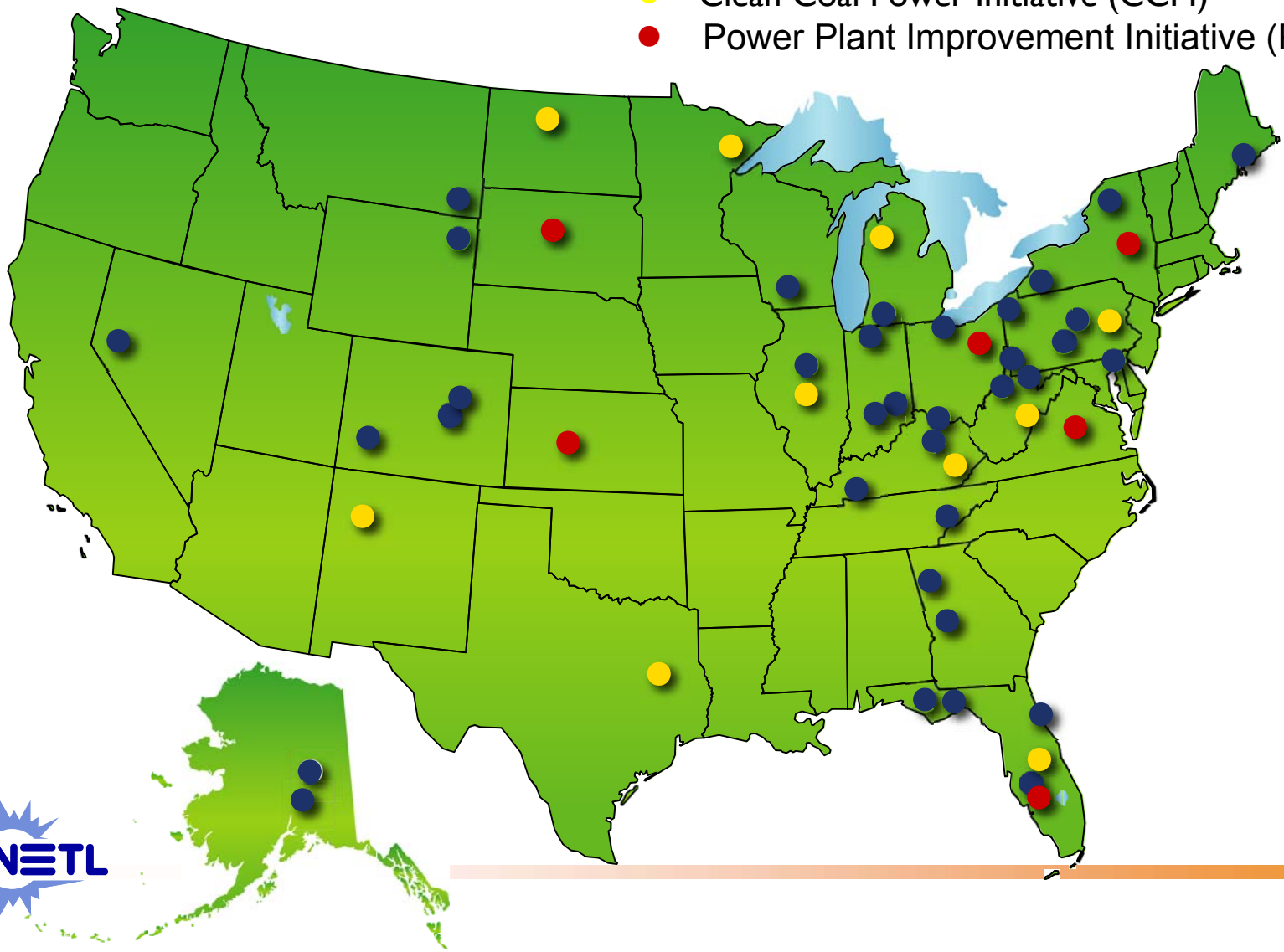
DOE's Coal Demonstration Programs

Implemented Through Competition



Commercial Clean Coal Demonstration Projects

- Clean Coal Technology (CCT) Program
- Clean Coal Power Initiative (CCPI)
- Power Plant Improvement Initiative (PPII)



IGCC Technology in Early Demos
U.S. Coal-Fueled Plants

- **Wabash River**
  - 1996 Powerplant of Year Award*
  - Achieved 95% availability
- **Tampa Electric**
  - 1997 Powerplant of Year Award*
  - First dispatch power generator

Nation's first commercial-scale IGCC plants, each achieving
> 95% sulfur removal
≥ 90% NO_x reduction

**Power Magazine*

Pending IGCC Technology Demos

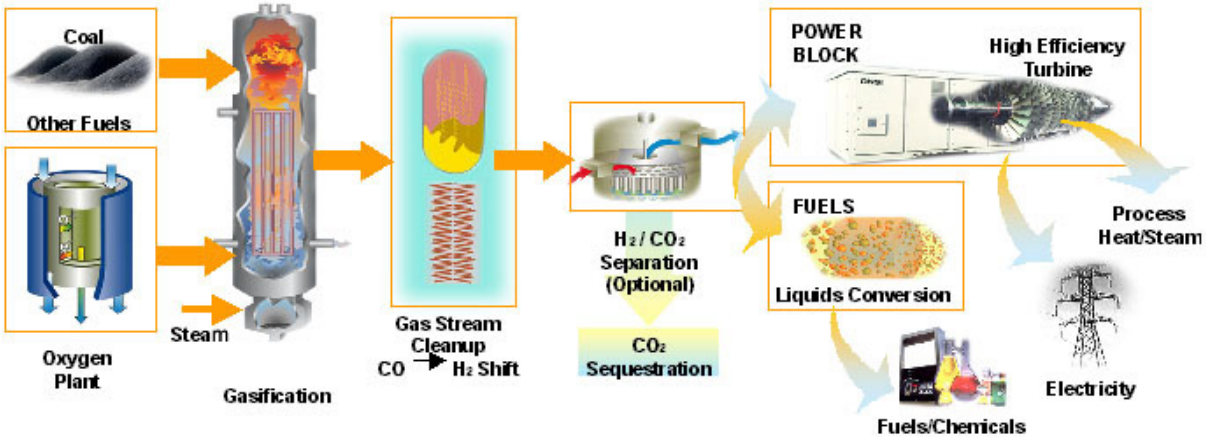
U.S. Coal-Fueled Plants

- **Waste Management and Processors Inc.**
  - Shell Gasifier, SASOL F/T – Gilberton, PA
  - Waste-coal and low-value fuel resources
  - Electrical power - 41 MWe
  - Liquid fuels 5,000 bpd
  - Total project funding: $612 million (DOE share: $100 million).
- **Southern Company Services**
  - Kellogg Brown & Root / Southern Company – Orlando, Fl
  - Air Blown / Transport Gasifier
  - Sub-bituminous PRB coal - 285 MW
  - Project Cost: $557 million (DOE share: $235 million)
- **Mesaba Energy**
  - ConocoPhillips' E-Gas™ - Iron Range, Mn
  - Fuel Flexible - 600 MWe
  - Project Cost $1,185 M (DOE share: $36 M)

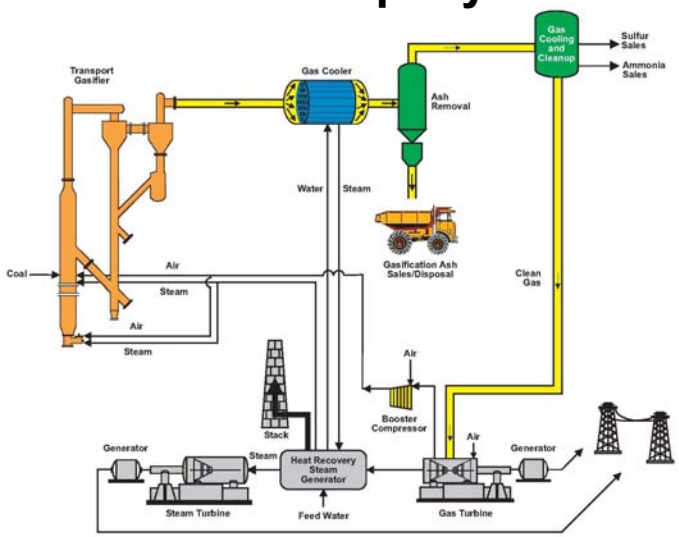
Pending IGCC Technology Demos

U.S. Coal-Fueled Plants

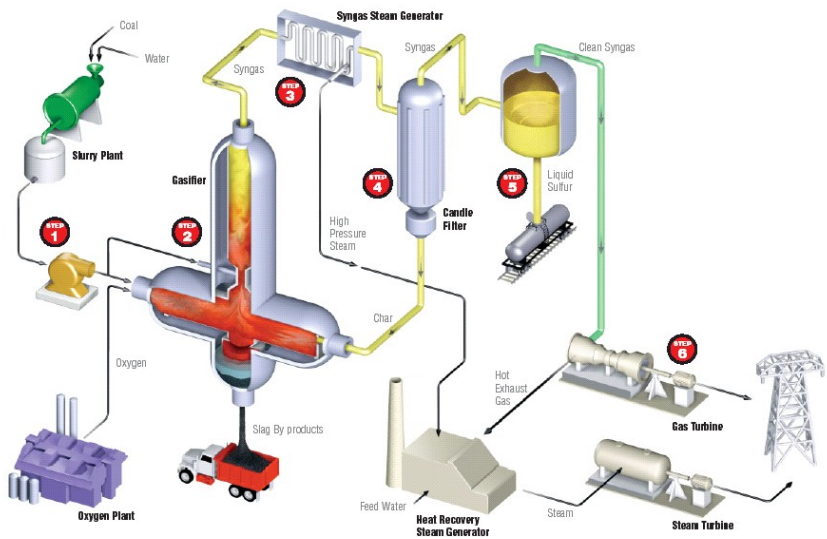
- **Waste Management and Processors Inc.**



- **Southern Company Services**



- **Mesaba Energy**



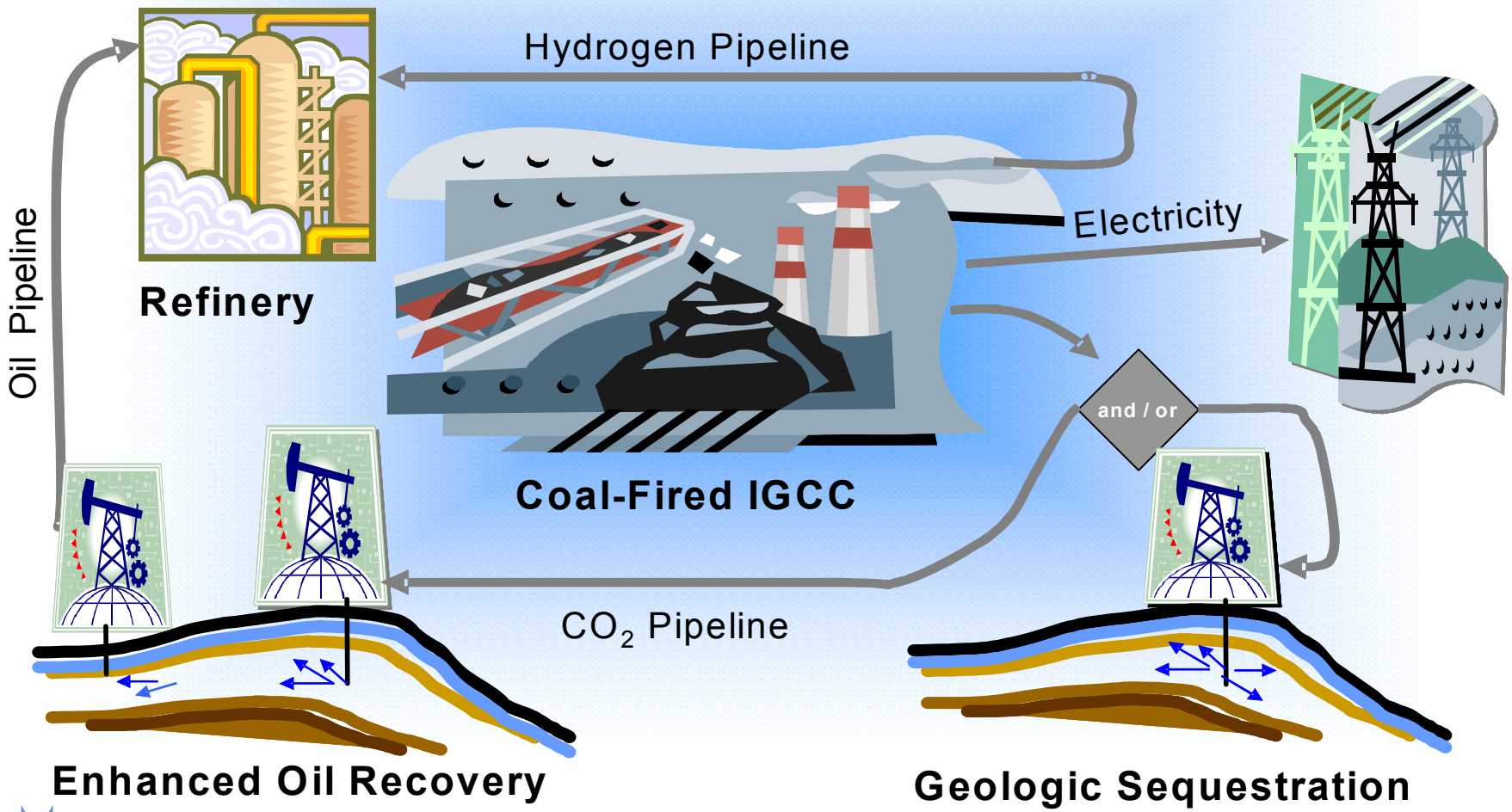
Combined National Emissions Reductions Potential[1] from Round 1&2 CCPI and PPII Technologies (tons/year)

Program	SO_2	NOx	PM	Hg	CO_2
CCPI 1Total	3,616,600	783,500	46,600	14.15	8,884,800
CCPI 2 Total	773,154	568,532	7450	6.7	14,403,800
PPII Total	232,800	242,000	54,100	--	6,114,000
Combined TOTAL	**4,622,554**	**1,594,032**	**108,150**	**20.85**	**29,402,600**
Emissions from All Boilers in U.S.	**10,149,019**	**3,856,988**	**522,400**	**46.6**	**2,114,078,779**

[1]Impact of technology through commercialization. Assumes reasonable market penetration.

FutureGen

Power, Hydrogen, & Sequestration Research Plant



FutureGen Industrial Alliance, Inc.

- **Non-profit**
- **8 members**
  - American Electric Power
  - Foundation Coal
  - BHP Billiton
  - Kennecott Energy
  - China Huaneng Group
  - Peabody Energy
  - CONSOL Energy
  - Southern Company

FutureGen Cost and Schedule

Project Definition
Partnership development; site selection; NEPA; preliminary engineering

Funding

DOE	$620
Industry	250
International	80
	$950

Engineering & Procurement
Detailed design; permitting; long-lead time procurement items

Plant Operation
Operate plant; monitor reservoir; introduce advanced technologies

Plant Construction
Prepare site; install gasifier/gas cleanup/ combined cycle/air separation; start up

2005 2009 2012

Year

NETL's Mission

Implement a research, development, and demonstration program to resolve the environmental, supply, and reliability constraints of producing and using fossil resources

National Energy Technology Laboratory

- DOE national lab dedicated to fossil energy
- Five locations
- 1,200 employees
- Fundamental science → commercial demonstrations

Pennsylvania

Oregon

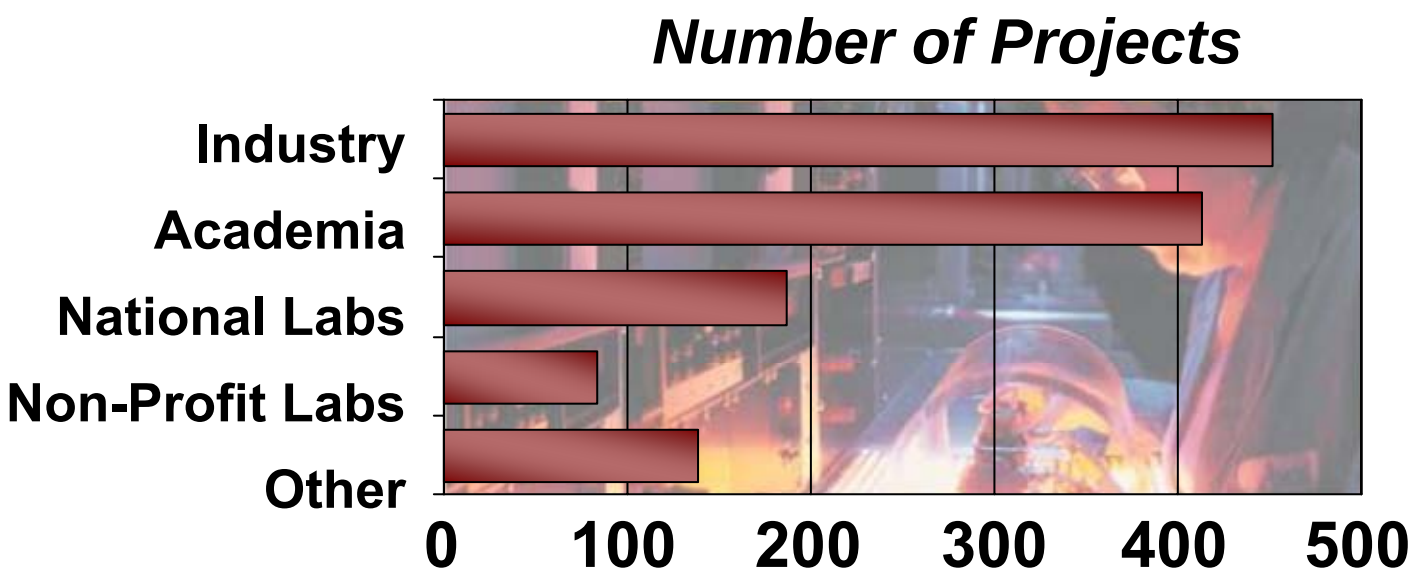
West Virginia

Alaska

Oklahoma

NETL's Research Portfolio

- **1,200 research activities**
  - 47 states
  - > 40 foreign countries
  - > $8 billion
- **Cost-sharing > $4 billion**



Updated 10/30/05

Working Together on Growing Energy Needs

www.netl.doe.gov