



Oxy-combustion Technology Research through the DOE-NETL Existing Plants Capture Program

August 12, 2010



National Energy Technology Laboratory

- *Full-service DOE Federal laboratory*
- *Dedicated to energy RD&D, domestic energy resources*
- *Fundamental science through technology demonstration*
- *Unique industry–academia–government collaborations*



Oregon

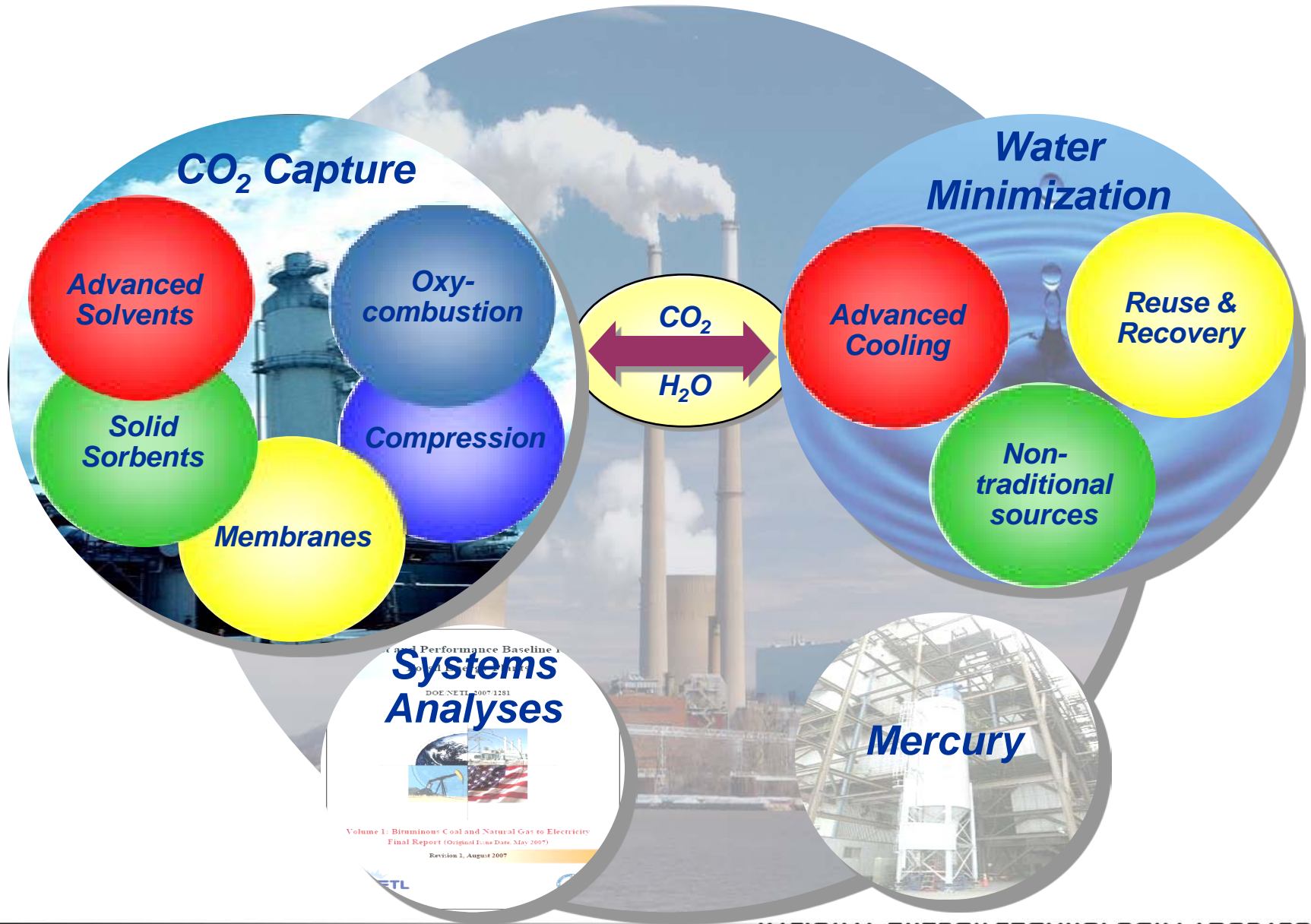


Pennsylvania

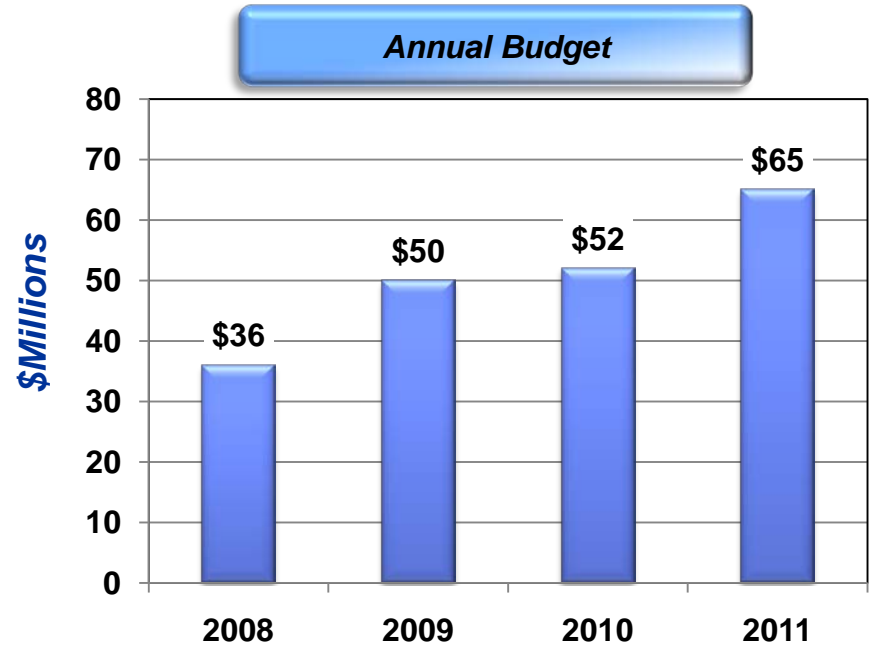
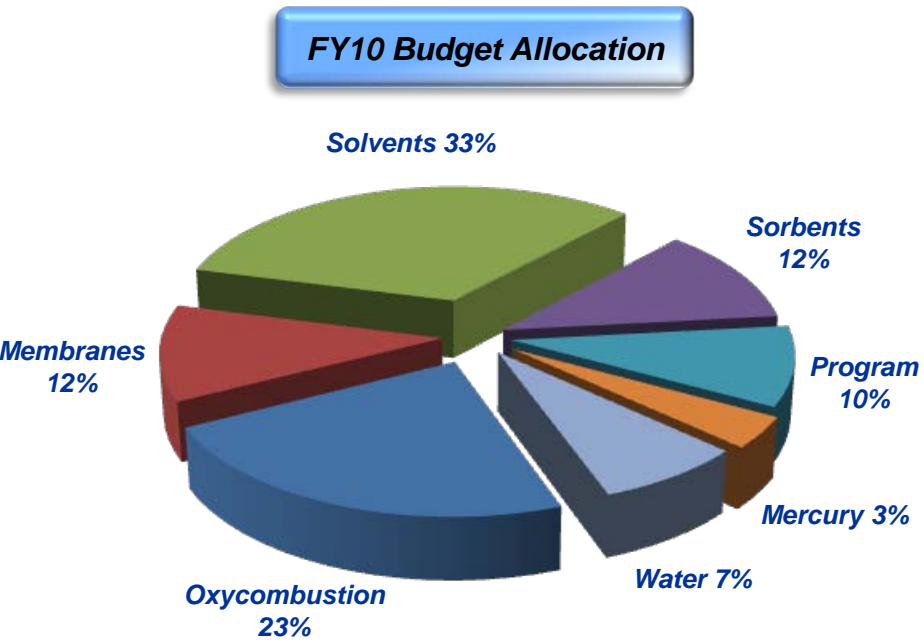


West Virginia

DOE's IEP Program Structure



IEP Program Budget



45 Total Projects

Organizations

• Industry	17
• University	8
• National Laboratories	4
• Non-Profit	6
Total	35

DOE/NETL CCS Program Goals

By 2020, have available for commercial deployment, technologies and best practices for achieving:

90% CO₂ capture

99%+ storage permanence

Pre-combustion Capture (IGCC)

< 10% increase in COE¹

Post- and Oxy-combustion Capture

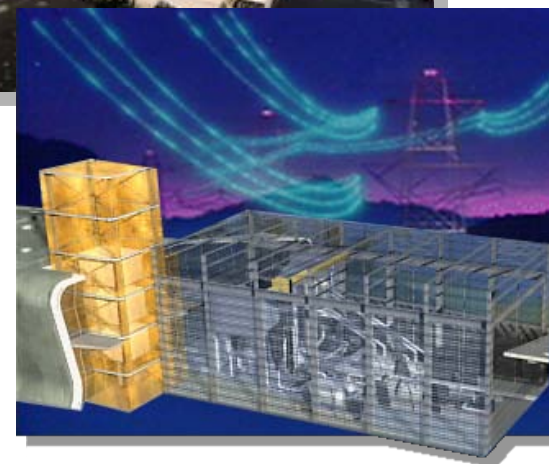
< 35% increase in COE²

**Cost of Electricity includes 50 mile pipeline transport and saline formation storage, 100 years of monitoring*

1. *Impact of Cost Escalation on Power Systems R&D Goals—Re-baselining APS, CS & FC GPRA R&D Goals, DOE/NETL July 2008*
2. *Existing Plants, Emissions & Capture Program—Setting Program Goals, U.S. DOE/National Energy Technology Laboratory, Draft Final Report, February 2009*

IEP CO₂ Emissions Control R&D Activities

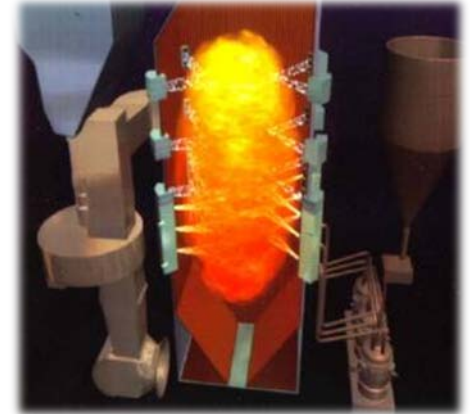
- Post-Combustion CO₂ Control
 - **Solvents**
 - **Sorbents**
 - **Membranes**
- Oxy-Combustion CO₂ Control
 - Chemical looping
- CO₂ Compression



Oxy-combustion Technologies

R&D Focus

- *New oxyfuel boilers*
 - *Advanced materials and burners*
 - *Corrosion*
- *Retrofit existing air boilers*
 - *Air leakage,*
 - *Heat transfer, corrosion*
- *Low-cost oxygen*
- *CO₂ purification*
- *Co-capture (CO₂ + SO_x, NO_x, O₂)*



Partners

- **Jupiter Oxygen Corporation**
- **Babcock & Wilcox**
- **Air Products**
- **Alstom**
- **Foster Wheeler**
- **Praxair**
- **Reaction Engineering International**
- **Southern Research**

Oxy-combustion Projects Summary

Performer (Project ID)	Coal Type(s) Tested	Firing Configuration(s)	Test Size in MW _{th}	Additional Info
Alstom (NT41146)	Bituminous	CFB	3.0	CO ₂ simulated recycle gas
Air Liquide (NT41586)	Sub-bituminous	Wall	1.5	CO ₂ simulated recycle gas
Alstom (NT42205)	Bituminous	CFB	3.0	CO ₂ simulated recycle gas
Southern Research (NT42430)	Bituminous Sub-bituminous	Wall	1.0	Recycled flue gas retrofit
B&W (NT42747)	Bituminous Sub-bituminous Lignite	Cyclone Wall	1.8	Recycled flue gas retrofit
Linde (NT42748)	Bituminous Sub-bituminous Lignite	T-fired	0.08	Baseline Tests for CAR system testing
Jupiter Oxygen (NT42811)	Bituminous	Wall	15	Recycled flue gas retrofit
REI (NT05288)	Bituminous Sub-bituminous	Wall	0.1, 1.2	Detailed mechanism development
Alstom (NT05290)	Bituminous Sub-bituminous Lignite	T-fired	15	Recycled flue gas retrofit

Oxy-Combustion for Tangential-Fired Boiler

Alstom Power

- **Pilot-scale tests at 15 MWth**
- **Goal is to minimize capital and operating costs**
- **Status:**
 - Completed test campaigns on PRB, low S Bituminous, high S Bituminous



BSF Test Campaign 1 & 2 Results

Alstom Power

- **Stable operation over a broad range of test conditions**
- **Ability to produce >90% CO₂ Flue Gas (dry basis)**
- **For both PRB and WV Bituminous:**
 - Able to operate at low excess O₂ (<2% at Economizer Outlet)
 - Low CO Emissions (near Zero)
 - Low Carbon in Fly ash
 - Lower NO_x under oxy-firing
 - Roughly 50% reduction from air-fired on lb NO_x/MMBtu
- **Heat transfer profile adjustable by changing operating conditions**
- **SO₂ to SO₃ conversion similar; SO₃ conc. 3x higher than air-fired**

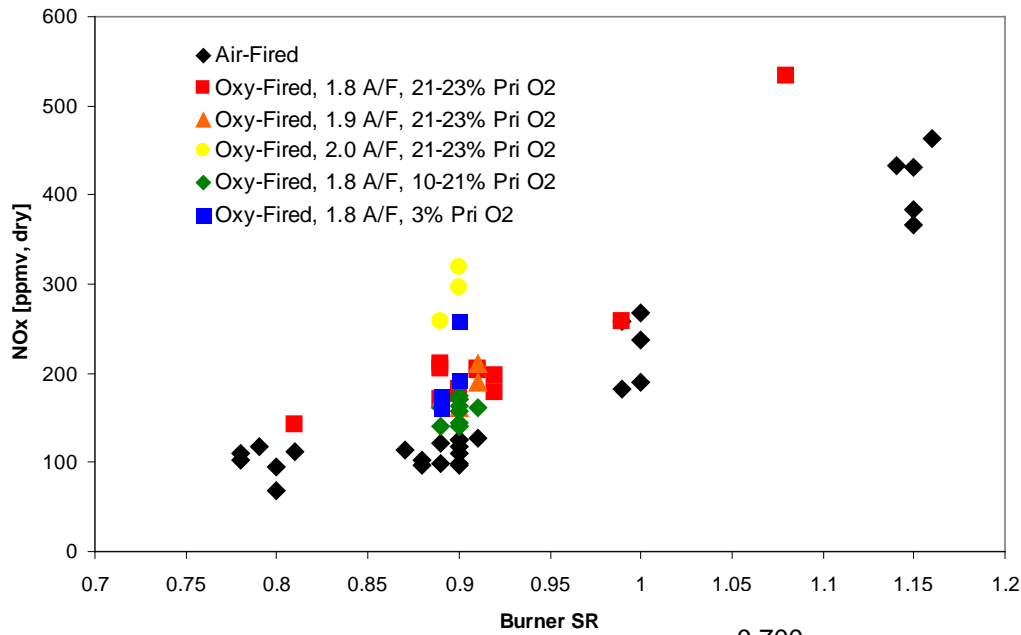
Oxy-combustion Impacts on Existing Coal-fired Boilers

Reaction Engineering International

- Evaluate impacts of retrofitting existing coal-fired boilers for oxy-combustion
- Multi-scale experiments (0.1 kW, 100 kW, 1.2 MW)
- Computational fluid dynamic modeling



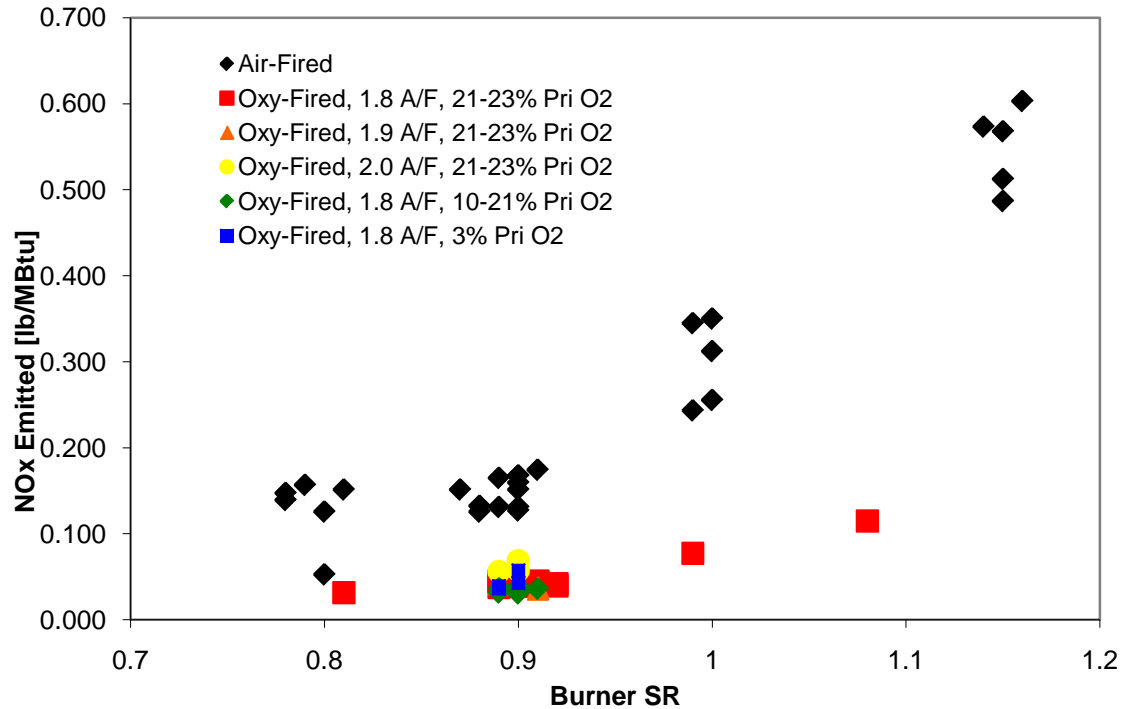
REI Testing Results (1.2 MWth)



Flame Stability

- Match Air-fired**
- Momentum
 - Gas/Fuel Mass Ratio
 - Primary Velocity

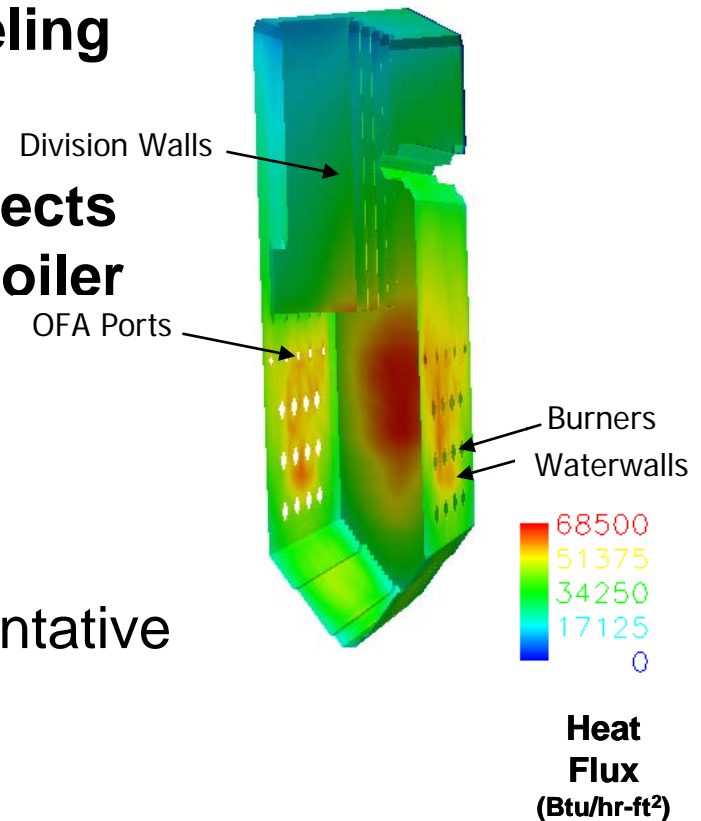
- Flame Behavior**
- Attached
 - Attached
 - Detached



Boiler Material Development for Oxy-Combustion

Foster Wheeler NA, Corp.

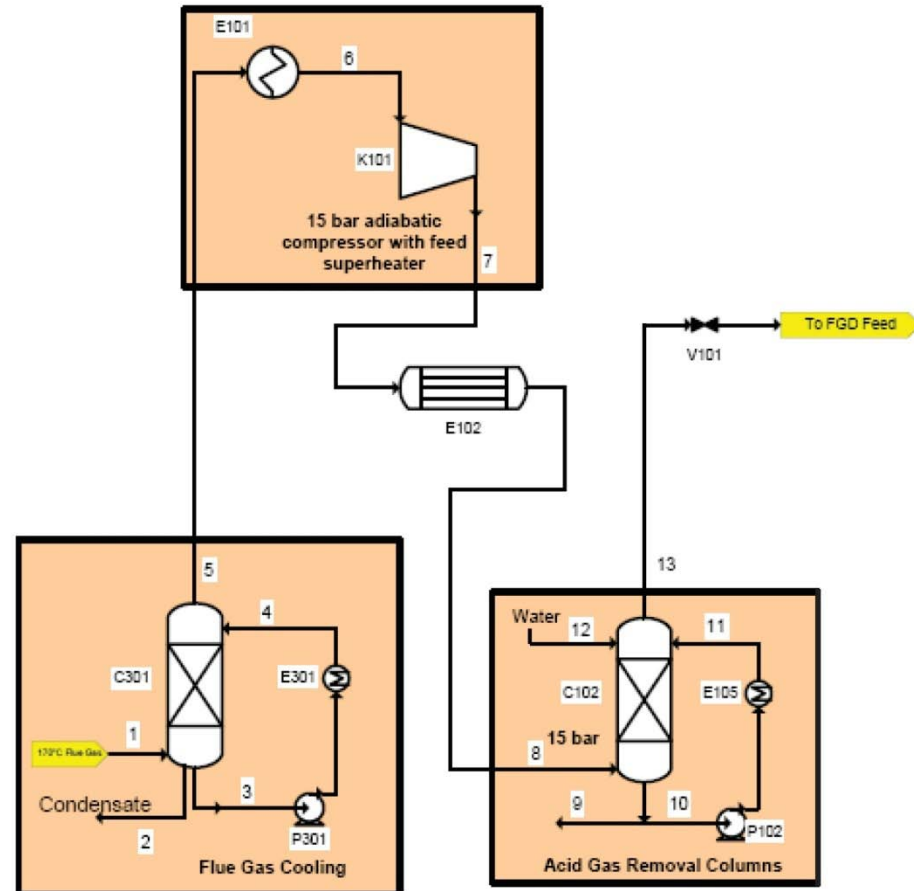
- Investigation of oxy-combustion effects on durability of boiler tube materials
- Computational fluid dynamic modeling will predict gas compositions
- Laboratory testing to determine effects on conventional and higher-alloy boiler tubes
- Testing 10 Waterwall & 10 Superheater/Reheater Materials
 - Each material coated with representative deposits
- Air and oxy-fired conditions



Flue Gas Purification for Oxy-Combustion

Air Products and Chemicals, Inc.

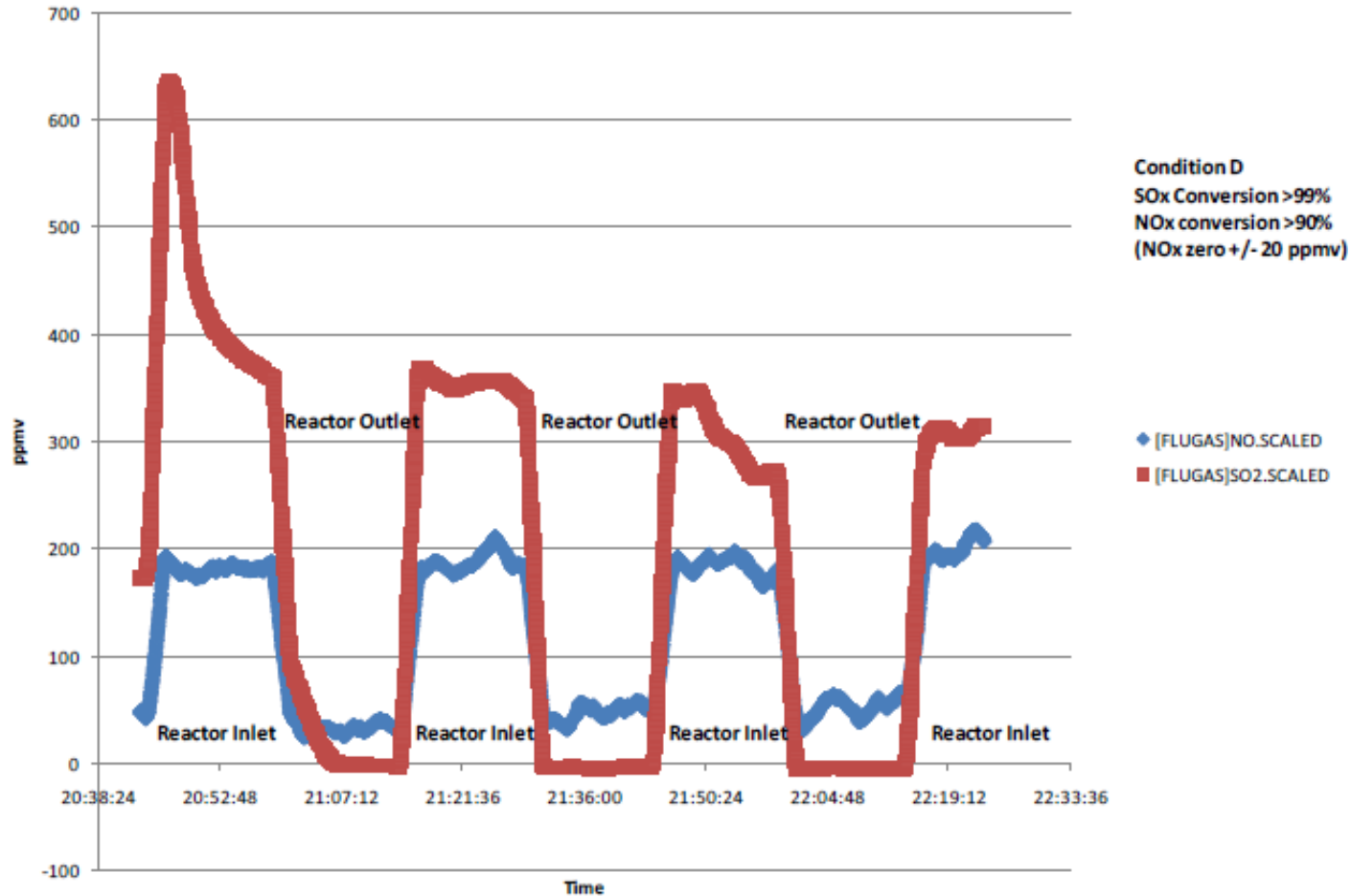
- **CO₂ may need to be cleaned of acidic impurities such as HCl and SO₂ before being transported by pipeline for sequestration**
- **Feasibility of purifying CO₂ from oxy-combustion will be studied**
 1. SO₂/NO_x removal at 1-30 atmospheres pressure
 2. Inert removal at 30-110 atmospheres pressure



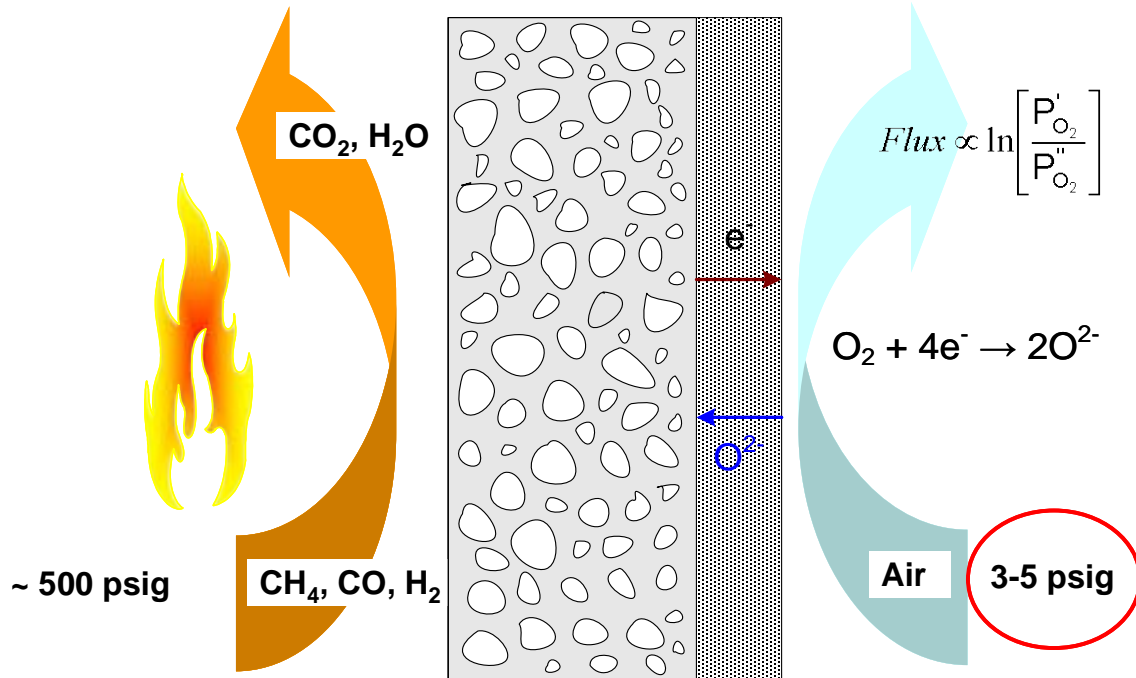
WV Bituminous Test Results

Air Products and Chemicals, Inc.

Oxyfuel 22 January 2010

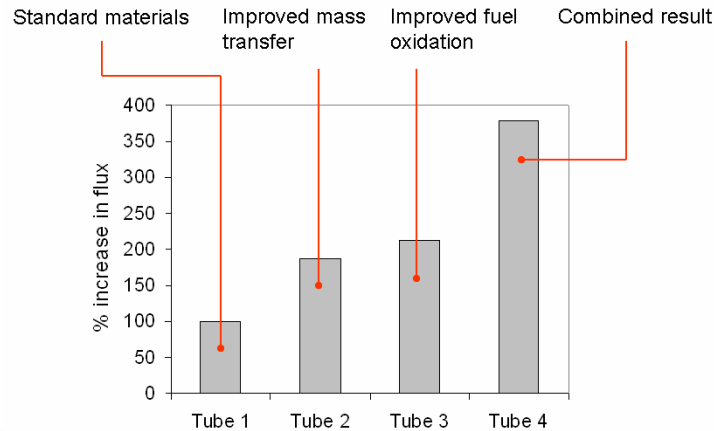


OTM Based Oxy-combustion for CO₂ Capture from Coal Power Plants



Step-change Technology

- Reduced O₂ power cost (~75%)
- Reliability at pressure and with gaseous fuel impurities

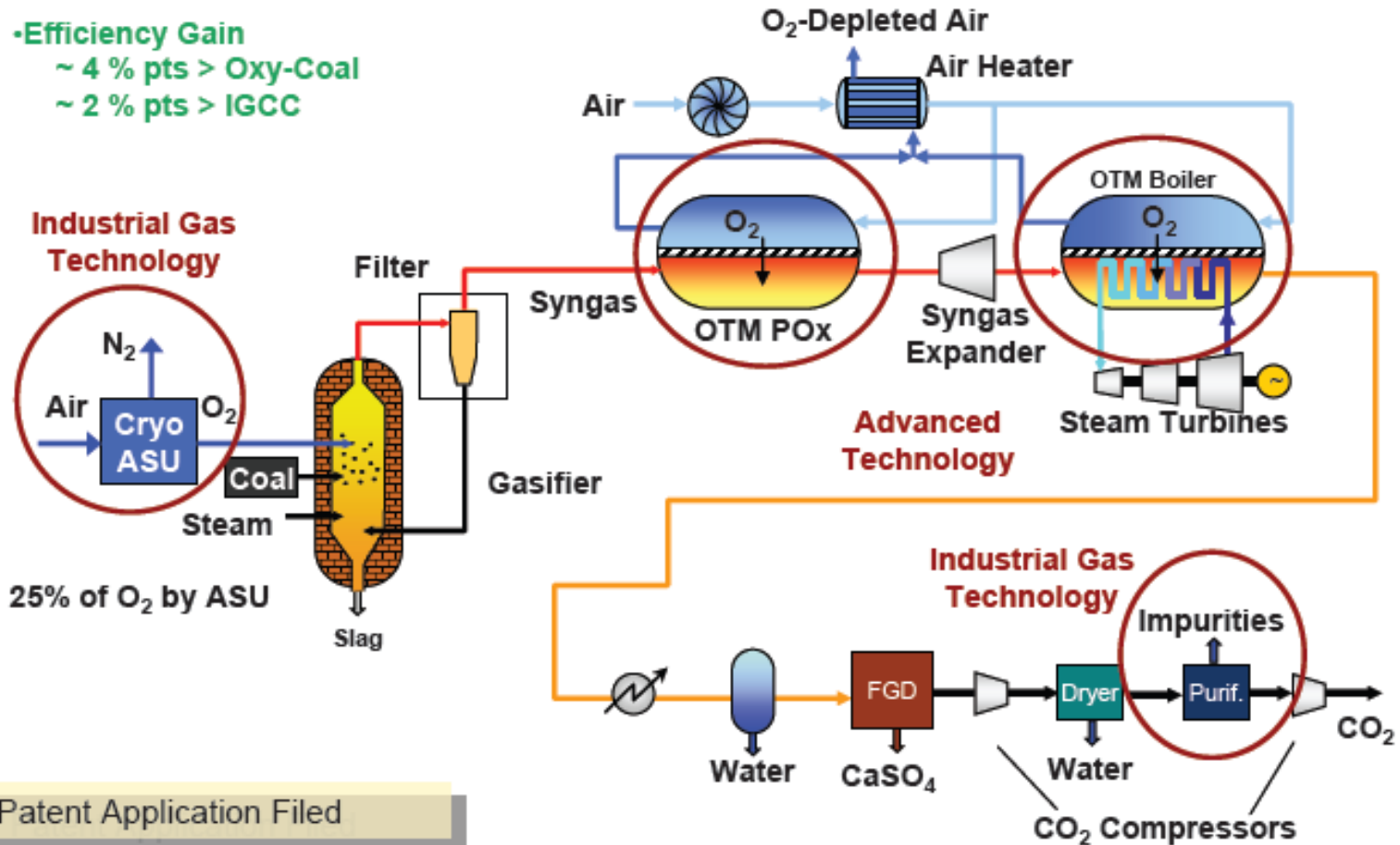


Participants: Praxair, University of Utah

NATIONAL ENERGY TECHNOLOGY LABORATORY

OTM Based Oxy-combustion for CO₂ Capture from Coal Power Plants

- Efficiency Gain
 - ~ 4 % pts > Oxy-Coal
 - ~ 2 % pts > IGCC



To Find Out More About NETL's CO₂ Capture R&D:

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ABOUT NETL	Home > Technologies > Coal & Power Systems > Innovations for Existing Plants	NEWS & FEATURES // All >
KEY ISSUES & MANDATES	Coal and Power Systems Innovations for Existing Plants	<ul style="list-style-type: none"> ▶ An Update on DOE/NETL's Mercury Control Technology Field Testing Program, Jan 2008 [PDF-322KB] ▶ Further Investigation of the Impact of Sulfur Trioxide on Activated Carbon Injection Performance, Nov. 2007 ▶ UPDATED Economic Analysis of Activated Carbon Injection, May 2007 [PDF-1.7MB] ▶ Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water, Dec. 2006 [PDF-2.5MB] ▶ Freshwater Needs Projected for Future Fleet, Sept. 2007 [PDF-1.4MB]
ONSITE RESEARCH	<ul style="list-style-type: none"> ▶ Funding Opportunity Announcement DE-PS26-08NT00233 entitled "Research and Development of Advanced Technologies and Concepts for Minimization of Freshwater Withdrawal and Consumption in Coal-Based Thermoelectric Power Plants." <i>Applications due April 21, 2008.</i> ▶ Funding Opportunity Announcement DE-PS26-08NT00134 entitled "Carbon Dioxide Capture and Separation Technology Development For Application To Existing Pulverized Coal-Fired Power Plants." <i>Applications due April 10, 2008.</i> 	EVENTS CALENDAR // All >
TECHNOLOGIES	<p>Welcome to the Innovations for Existing Plants homepage. The The Innovations for Existing Plants (IEP) Program is an integral part of NETL's Coal and Power Systems RD&D portfolio. Coal is a vital energy resource in the United States, providing approximately half of the electricity supply to the country.</p> <p>Through the IEP Program we are striving to sustain the strategic role of coal in the nation's energy mix by maintaining its integrity as an affordable and environmentally sound natural resource. Our program mission is to develop innovative environmental control technologies that will enable full use of the nation's vast coal reserves, while at the same time allowing the current fleet</p>	<ul style="list-style-type: none"> ▶ DOE/NETL Seventh Annual Conference on Carbon Capture & Sequestration Pittsburgh, PA May 5-8, 2008
<ul style="list-style-type: none"> Oil & Natural Gas Supply Coal & Power Systems <ul style="list-style-type: none"> ▶ Clean Coal Demonstrations ▶ Innovations for Existing Plants ▶ Gasification ▶ Turbines ▶ Fuel Cells ▶ FutureGen ▶ Adv. Research/Combustion ▶ Contacts Carbon Sequestration Hydrogen & Clean Fuels Technology Transfer 		PUBLICATIONS & PROJECTS // All >
ENERGY ANALYSES	<ul style="list-style-type: none"> ▶ CO₂ Emissions Control ▶ Water-Energy Interface ▶ Mercury Emissions Control ▶ Coal Utilization By-Products ▶ Advanced NOx Emissions Control ▶ Air Quality Research ▶ PM Emissions Control 	<ul style="list-style-type: none"> ▶ Water: A Critical Resource in the Thermoelectric Power Industry [PDF-426KB]
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<http://www.netl.doe.gov/technologies/coalpower/ewr/index.html>