NATIONAL ENERGY TECHNOLOGY LABORATORY

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

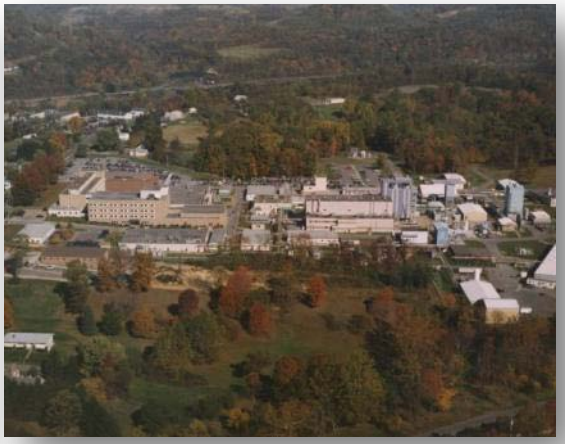
August 12, 2010

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*

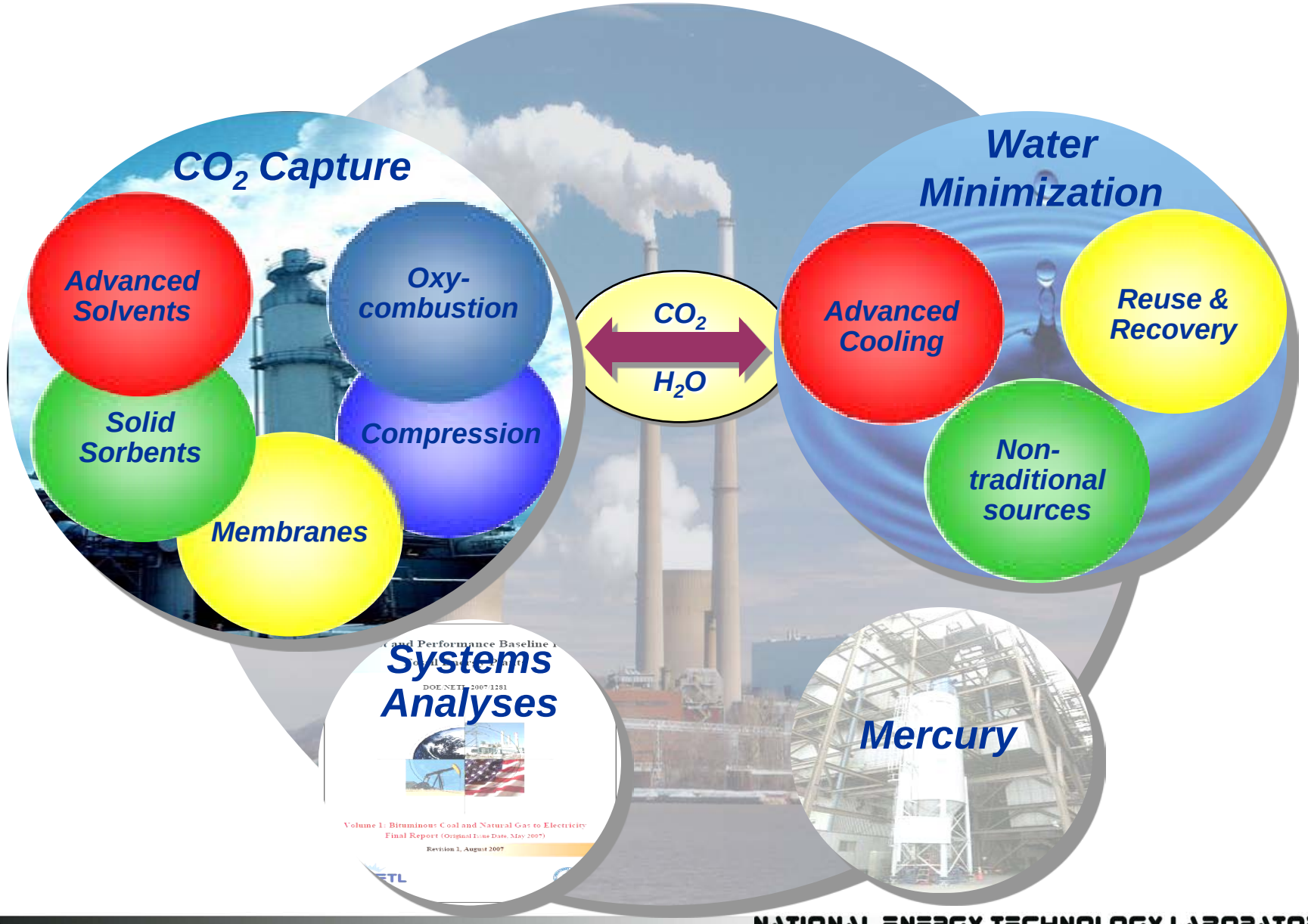
Oregon

Pennsylvania

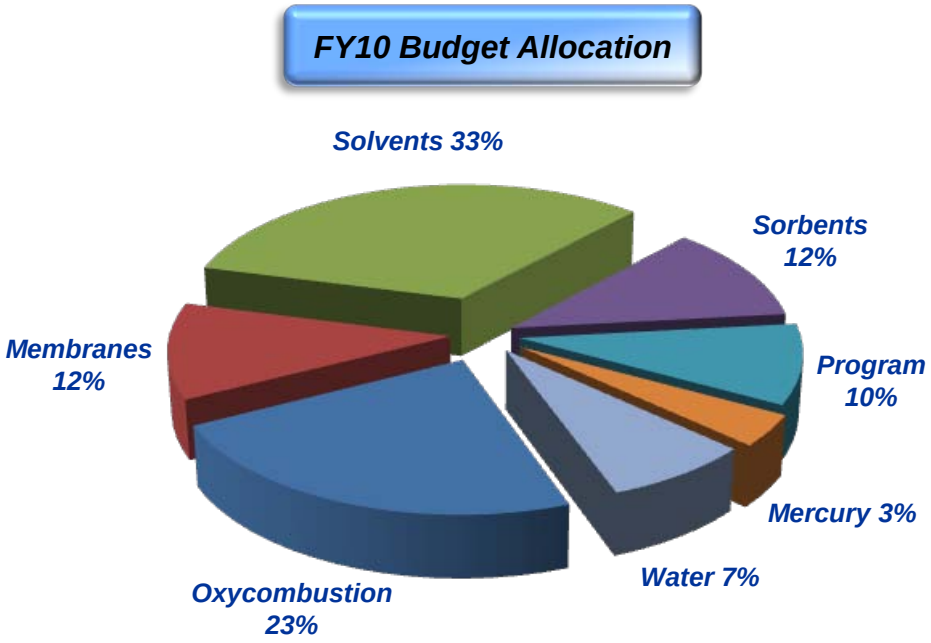


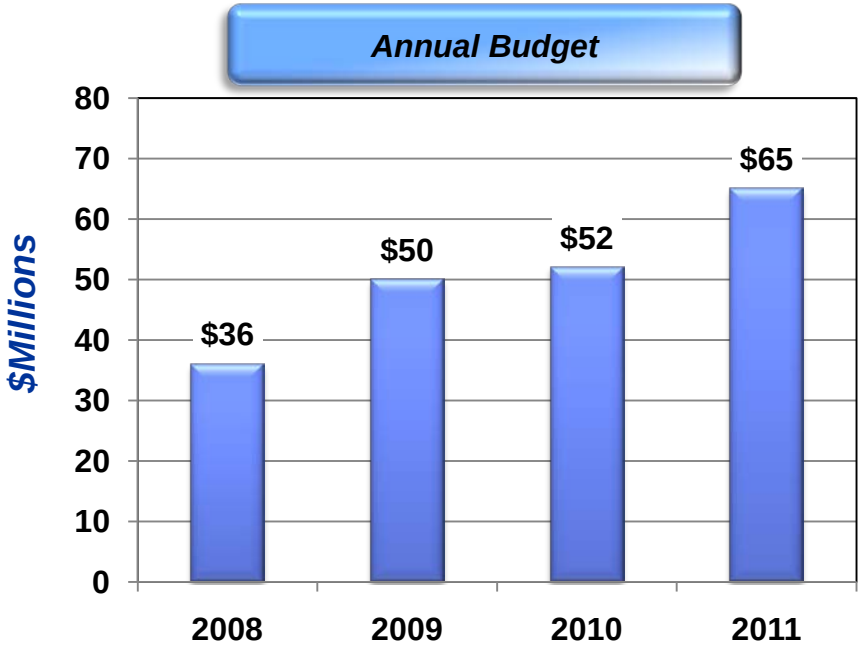
West Virginia

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% CO_2 capture

99%+ storage permanence

Pre-combustion Capture (IGCC)

< 10% increase in COE[1]

Post- and Oxy-combustion Capture

< 35% increase in COE[2]

**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*

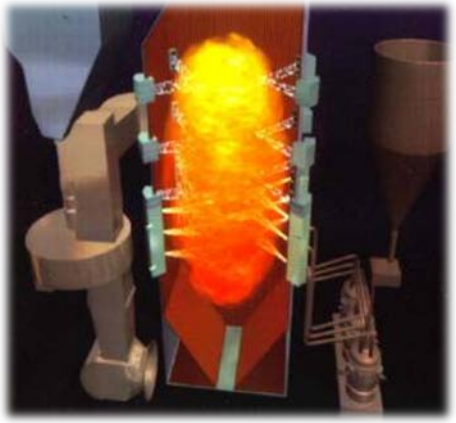
IEP CO_2 Emissions Control R&D Activities

- Post-Combustion CO_2 Control
  - **Solvents**
  - **Sorbents**
  - **Membranes**
- Oxy-Combustion CO_2 Control
  - Chemical looping
- CO_2 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*
- *CO_2 purification*
- *Co-capture (CO_2 + SOx, NOx, O_2)*



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

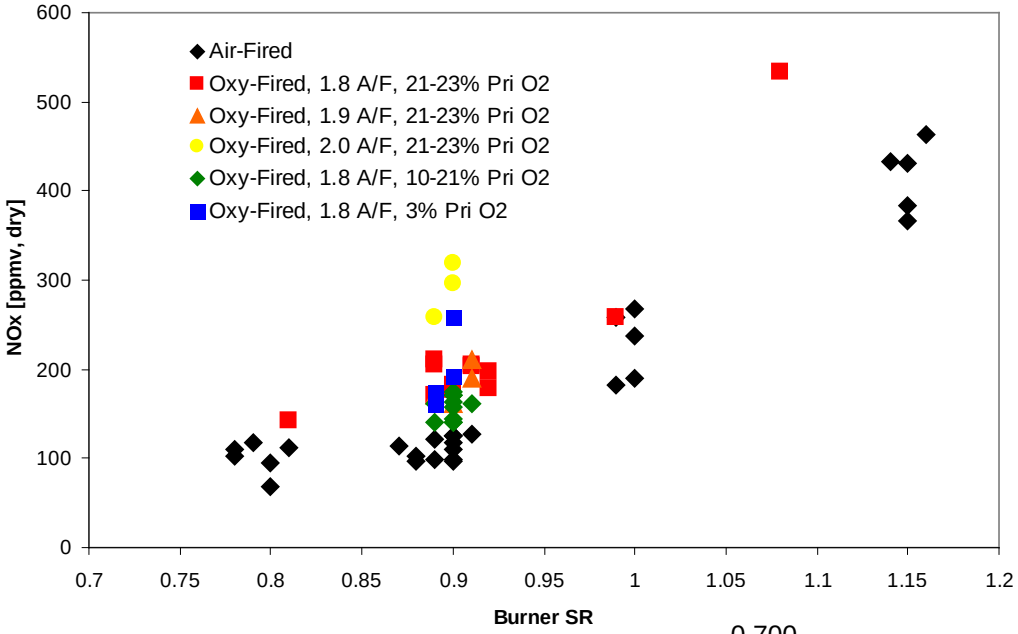
- **Stable operation over a broad range of test conditions**
- **Ability to produce >90% CO_2 Flue Gas (dry basis)**
- **For both PRB and WV Bituminous:**
  - Able to operate at low excess O_2 (<2% at Economizer Outlet)
  - Low CO Emissions (near Zero)
  - Low Carbon in Fly ash
  - Lower NO_x under oxy-firing
    - Roughly 50% reduction from air-fired on lb NO_x/MMBtu
- **Heat transfer profile adjustable by changing operating conditions**
- **SO_2 to SO_3 conversion similar; SO_3 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**

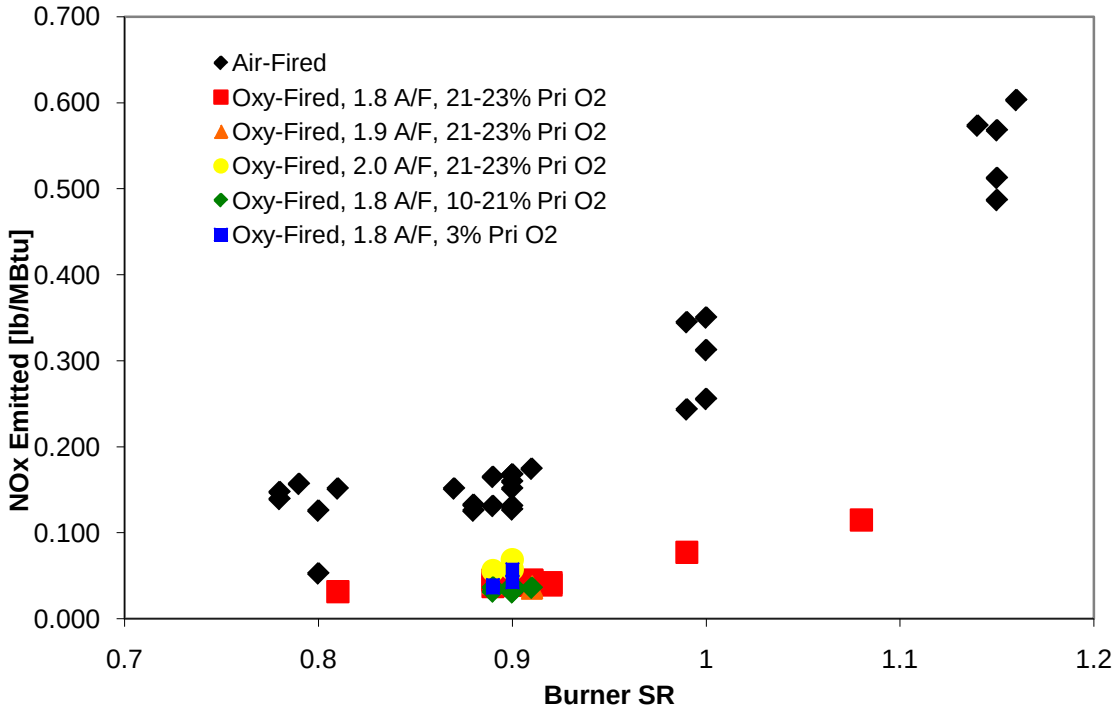
REI Testing Results (1.2 MWth)



Flame Stability

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

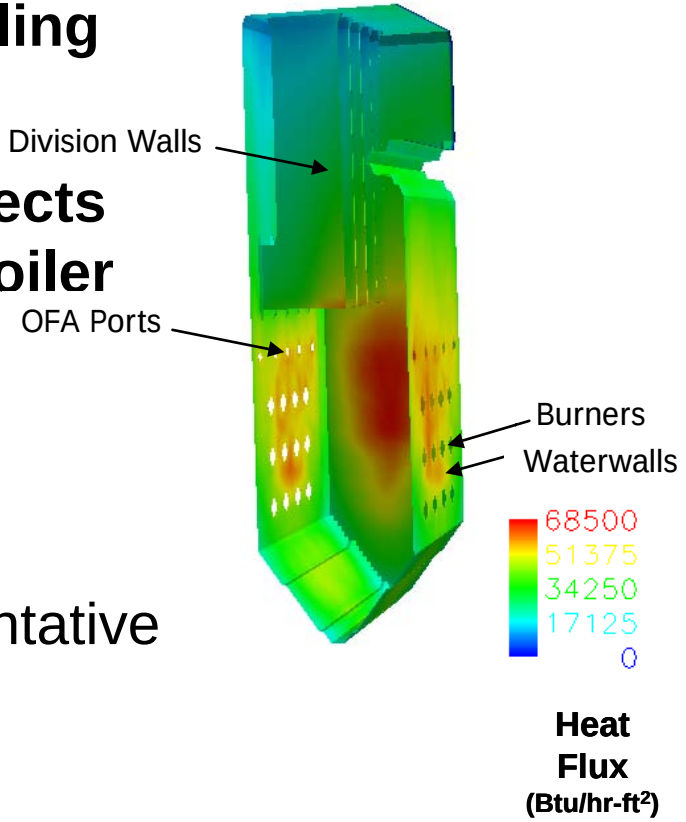
Flame Behavior
- **Attached**
- **Attached**
- **Detached**



Boiler Material Development for Oxy-Combustion

Foster Wheeler NA, Corp.

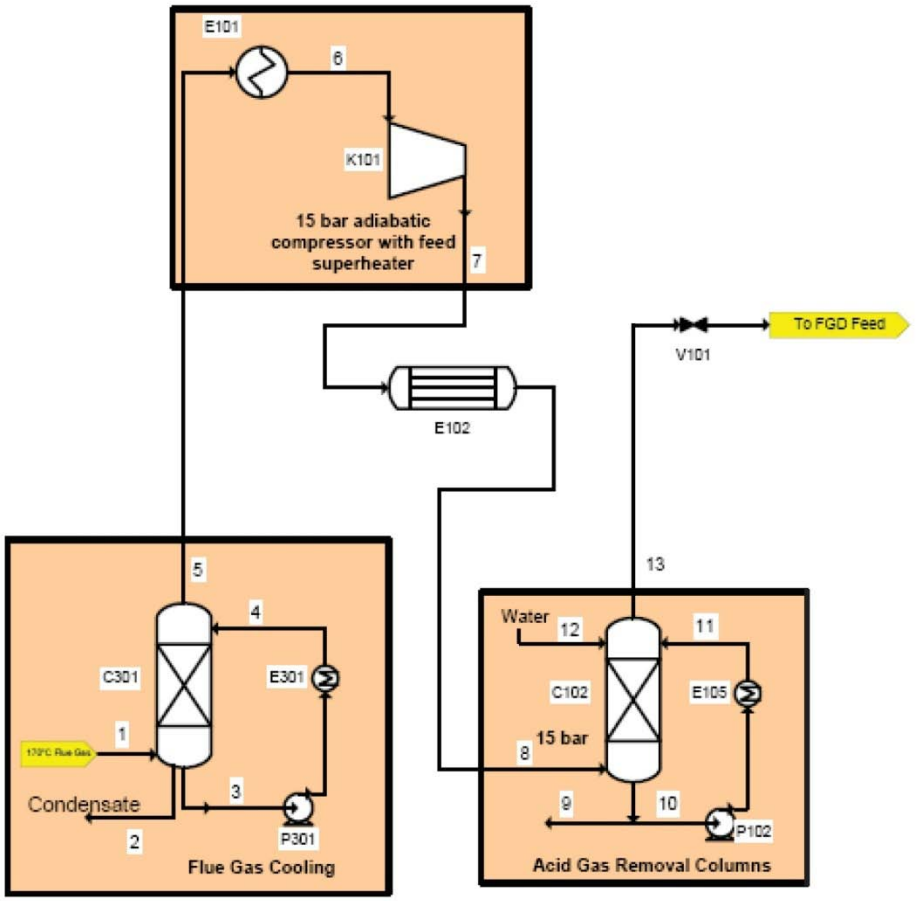
- **Investigation of oxy-combustion effects on durability of boiler tube materials**
- **Computational fluid dynamic modeling will predict gas compositions**
- **Laboratory testing to determine effects on conventional and higher-alloy boiler tubes**
- **Testing 10 Waterwall & 10 Superheater/Reheater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



Flue Gas Purification for Oxy-Combustion

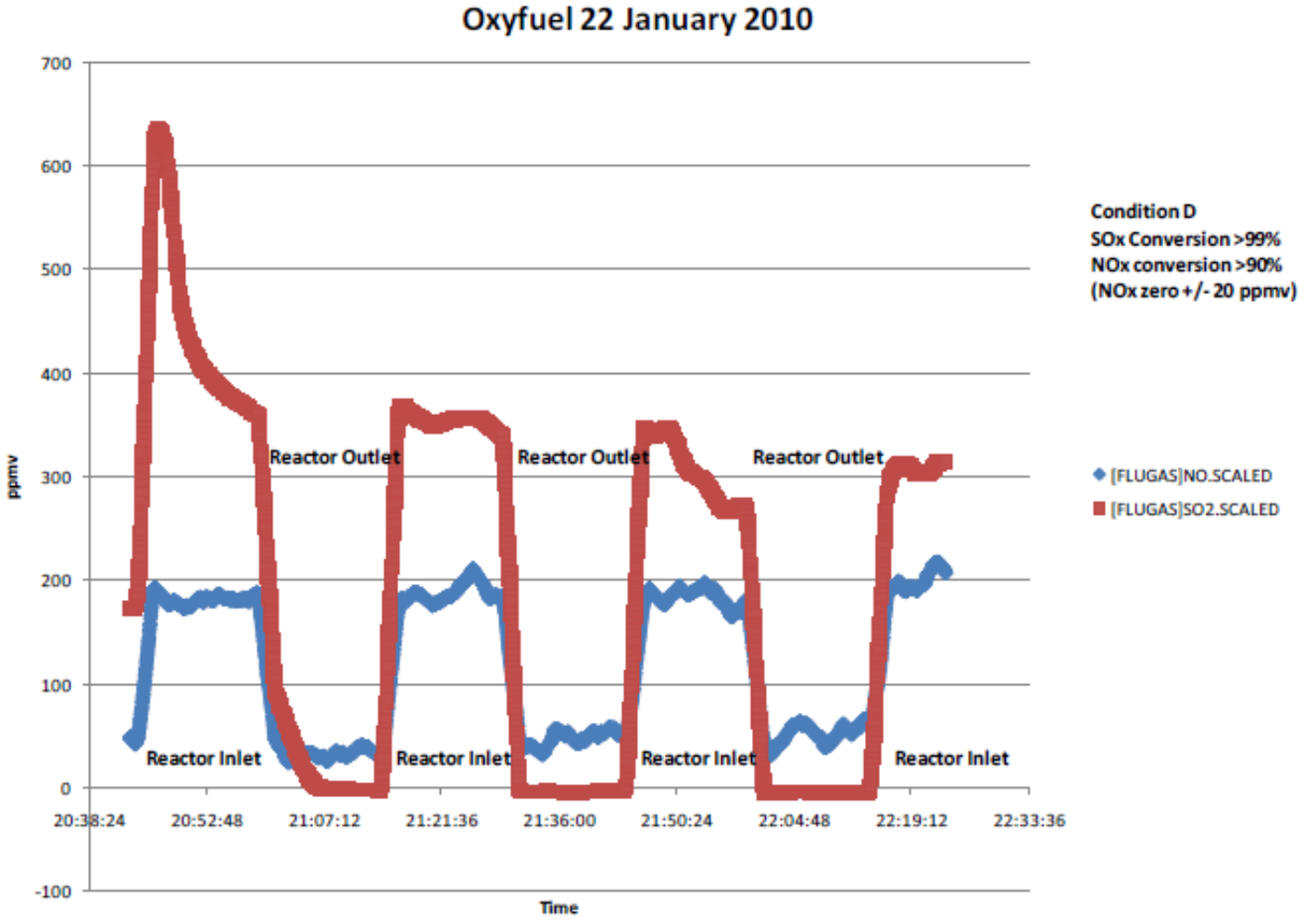
Air Products and Chemicals, Inc.

- **CO_2 may need to be cleaned of acidic impurities such as HCl and SO_2 before being transported by pipeline for sequestration**
- **Feasibility of purifying CO_2 from oxy-combustion will be studied**
    1. SO_2/NOx removal at 1-30 atmospheres pressure
    2. Inert removal at 30-110 atmospheres pressure

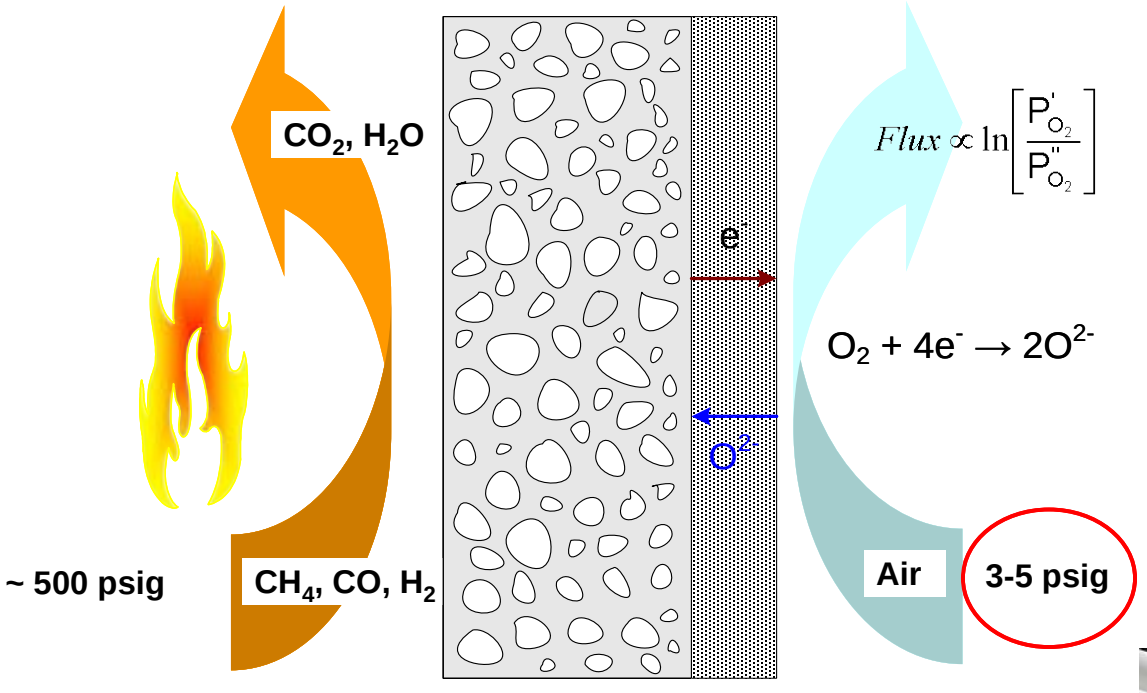


WV Bituminous Test Results

Air Products and Chemicals, Inc.

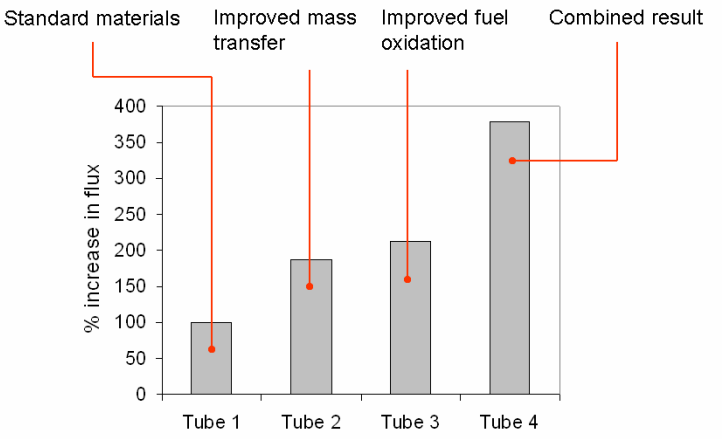


OTM Based Oxy-combustion for CO_2 Capture from Coal Power Plants



Step-change Technology

- *Reduced O_2 power cost (~75%)*
- *Reliability at pressure and with gaseous fuel impurities*



Participants: Praxair, University of Utah

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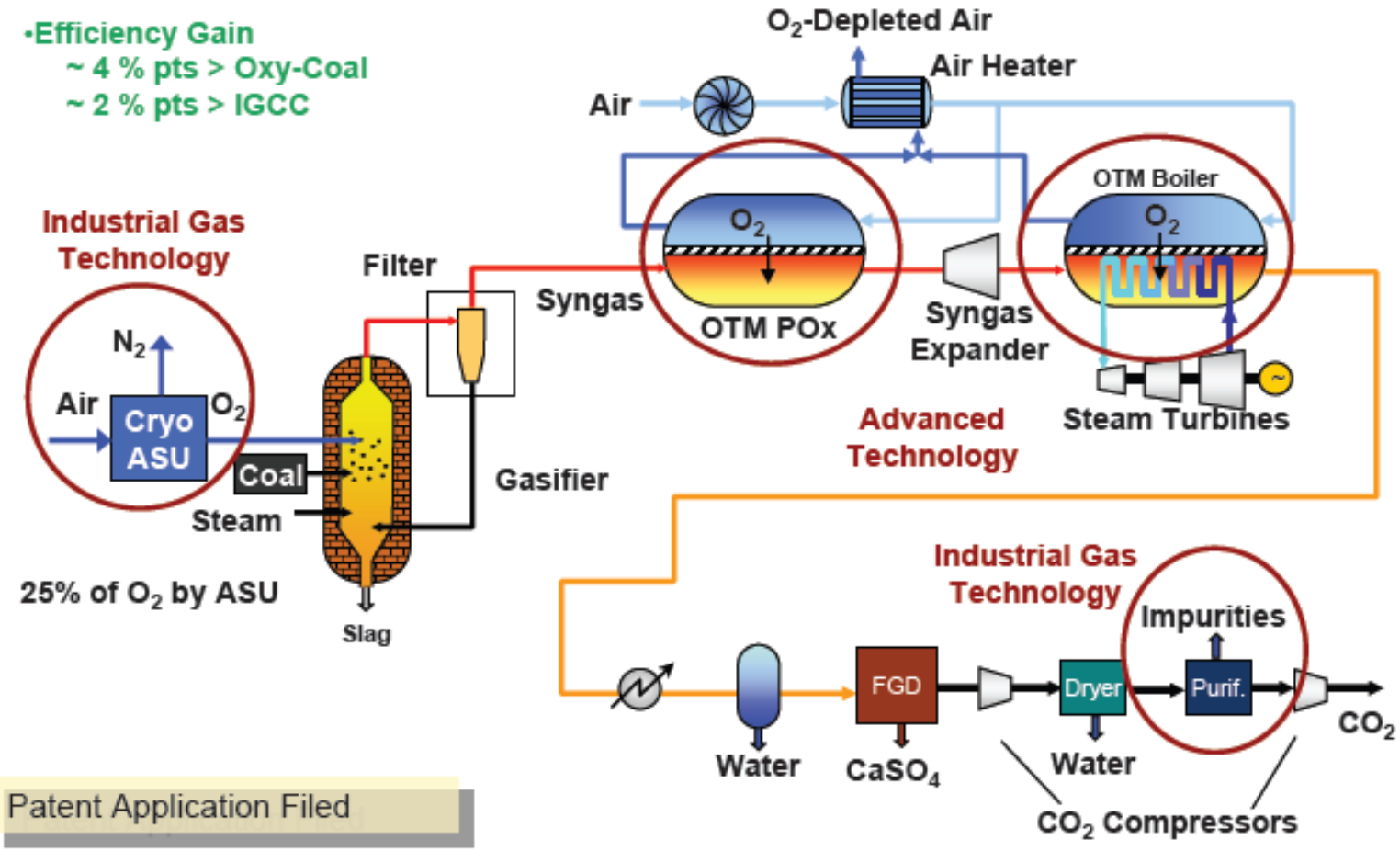

Patent Application Filed

To Find Out More About NETL's CO_2 Capture R&D:

http://www.netl.doe.gov/technologies/coalpower/ewr/index.html