Oxy-Coal Combustion Pilot
IEAGHG International Oxy-Combustion Network;
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Why Oxy-Coal Combustion?

Oxy-coal combustion has reasonable potential to be the lowest cost, highest efficiency, most reliable and easiest to deploy large scale carbon capture technology.

- Next generation improvements in progress
  - USC technology development
  - Reduction of recycle
  - Simplified moisture removal
  - Elimination of gas reheating
  - Total plant integration
New Product Commercialization – R&D Process

- Pilot-Scale Testing
- Process Simulation and Modeling
- Macro-Scale Testing
- Process Engineering and Economics
- Micro-Scale Testing
- Demonstration
30 MW<sub>th</sub> Oxy-Coal Tests at B&W Clean Environment Development Facility (CEDF) for CO<sub>2</sub> Capture

- Managed and funded by B&W, American Air Liquide, Inc. and Utility Advisory Group
- CEDF modified to use and mix oxygen, added WFGD, other auxiliary equipment for oxycoal
- Utility Advisory Group providing end user design feedback for commercial applications
- Test campaigns underway include Saskatchewan lignite, sub-bituminous (PRB) coal and eastern bituminous coal
30 MW<sub>th</sub> Test Facility located in Alliance, Ohio

- Built in 1994 with support of DOE and others
- 100 Million Btu/hr (30 MWth) input with coal
**CEDF Oxy-coal Campaign**

Expected Major Goals

- Optimum burner design for each coal
- NO\textsubscript{x} emissions
- Floxynator performance
- Pulverizer performance
- Furnace exit gas temperature
- Boiler/convection pass heat transfer
- Scrubber performance
  - SO\textsubscript{2} Control
  - SO\textsubscript{3}
- Potential enhancement of mercury speciation with oxy-combustion
- ESP performance
- Insights for materials development
- Air infiltration evaluations (future CPU design)
CEDF Furnace Views
# CEDF Oxy-Coal Campaign - Coals

<table>
<thead>
<tr>
<th></th>
<th>Mahoning 7 Eastern Bituminous</th>
<th>Black Thunder Western Sub-Bituminous</th>
<th>Shand Lignite</th>
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<tr>
<td>C</td>
<td>73.30</td>
<td>50.66</td>
<td>39.62</td>
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<tr>
<td>S</td>
<td>1.37</td>
<td>0.33</td>
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<tr>
<td>H</td>
<td>4.97</td>
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<tr>
<td>H\textsubscript{2}O</td>
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<tr>
<td>O</td>
<td>6.62</td>
<td>12.13</td>
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<td>Ash</td>
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<td>HHV, kJ/kg</td>
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CEDF Modifications for Oxy-coal Testing

- Recycle flue gas system and air intakes
- Oxygen supply and mixing system
- Moisture removal system
- Full flow wet flue gas desulphurization (WFGD) system
- Capability to direct fire (indirect-fired heater)
- Coal dryer for flexibility in testing
- Furnace panel for assessing heat flux and emissivity
- Instrumentation for data acquisition and control
  - Desired process parameters
  - Gas compositions at key locations
  - Mercury at selected locations
- Controls upgrade for new equipment
- Maintenance and preparation of existing equipment
  - Replace furnace refractory
  - Upgrade fan shaft seals
  - Service and refurbish all existing equipment
CEDF Modifications for Oxy-coal Testing

- Oxygen Mixers
- Wet Scrubber Tower
- Wet Scrubber Reaction Tank
- Indirect-fired Airheater
- Indirect-fired Baghouse
- Coal Dryer Baghouse
- Coal Dryer
- Power Generation Group
Oxy-coal CEDF - SO₂ Scrubber system installation

Recirc & Bleed Pumps

Tower Inlet Flue

WFGD Tower
240 tons/day Oxygen supply and distribution system

- 11,000 gal and 52,000 gal LOX tanks installation
- Sec. Floxynator™ installation
- LOX tanks & Ambient vaporizers
- Oxygen distribution system
CEDF Oxy-coal Program

- **Project Timeline**
  - Jan 2007: Start site demolition/construction
  - Jun 2007: Most major construction complete
  - Aug 2007: Component shakedown completed
  - Sep 2007: First fire on coal with oxygen
  - Oct 8 2007: First full oxy-transition at 80 MBtu/hr
  - Oct 2007: Begin baseline tests
  - Nov 2007: Three days continuous operation on oxygen, with bituminous coal
  - Dec 2007: First test campaign complete, 100+ hours
  - Early 2008: Lignite and sub-bituminous testing
Oxy-combustion CO₂ Control – 2007 Highlights

100+ hours in oxy mode (bituminous coal)

Oxy-coal Flame
CEDF Baseline Test Campaign #1

- Test Plan Objectives
  - Establish baseline for three major fuel types
  - Verify process parameters for full scale design
    - Multiple burner configurations, with pulverizer
    - Flue gas recycle with commercial O₂ mixing system
    - Wet scrubber
    - Flue gas moisture control

- Results to Date
  - CO₂: 70% (dry volume), air infiltration high
  - NOₓ: Similar to SBS tests, SBS achieved 60% reduction
  - CO: Low
  - SO₂: No noticeable change in wet scrubber removal
  - Transition: First two very smooth over several hours in manual
  - Stability: Burner very stable, brighter flame vs. air
Floxy

Floxy™ for O₂/FG Mixing

- Based on AL’s patented Oxynator™
  - Air/O₂ mixing
  - Radial injection with swirl
  - Low pressure drop
  - Commercial installations at 800 tons/day
- Challenges
  - Up to 10,000 tons/day O₂ mixing
  - Large turndown
  - Additional safety constraints
    - Flue gas impurities
    - Coal handling
- Floxy
  - Mixing in the center, safe-guarding the duct walls
  - Extensive numerical and bench scale tests
- Floxy™ concept successfully validated at CEDF

* TM, Patent pending
Oxy-combustion CO₂ Control – 2007 Highlights

LESSONS LEARNED SO FAR:

1. The process works.
2. Oxy flame is bright and stable
3. NOx is significantly reduced (>50%)
4. SO₂ removal not significantly different than with air
5. Safe and efficient mixing of O₂/flue gas with Floxynator
6. There’s more air infiltration at CEDF than expected
7. Transition is very controllable in both directions
8. Unit tripping at high load on oxygen is safely manageable and anticipated control scheme works
Dōmo Arigatō Gozaimasu