FutureGen 2.0
Oxy-Coal Carbon Capture and Storage Project

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Feb. 16, 2011

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Introduction
**The Babcock & Wilcox Company**

Leading technology innovator in power generation and nuclear components with a legacy spanning more than 140 years

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**Government Operations**

- Supplies components for submarines and aircraft carriers
- Provides various other services to U.S. Government, primarily within the nuclear weapons complex of the DOE

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**Power Generation Systems**

- Designs, engineers, manufactures and constructs large utility and industrial power generation systems
- Supplies fossil-fired boilers, commercial nuclear steam generators and components, and environmental equipment and related aftermarket parts and services
Power Generation – Fossil and Renewables

Global Reach

- Total Employees: ~ 8,700 Including JV employees
- Installed 38% of boilers in North American coal-fired power plants
- Supplied worldwide capacity of more than 300,000 MW in 800+ utilities in 90+ countries
- Manage operations and maintenance of North America power facilities

Product Line Portfolio

- **Traditional Power**
  - Steam Generation
  - Service and O&M (Operation & Maintenance)
  - Construction and EPC (Engineer-Procure-Construct)
  - Boiler Cleaning and Material Handling

- **Clean Coal**
  - Environmental Systems and Service
  - $SO_2$, NOx, Carbon, Mercury. PM

- **Renewables**
  - Biomass
  - Solar
  - Energy-from-Waste
  - Auxiliaries
The CCS Imperative – Deploy Now to Meet 2020 Imperative

FutureGen 2.0 Project

- 200 MWe coal-fired carbon capture and geologic storage project, in cooperation with the FutureGen Alliance, largely funded by the DOE
- Will employ Oxy-coal technology; studies/pilots confirm higher efficiency, lower emissions, lower overall cost
- High value to future of Illinois coal and power industries

Addressing Coal

- Interagency Task Force on Carbon Capture and Storage (released August 2010)
  - Propose a plan to overcome barriers to widespread CCS deployment by 2020, with 5 to 10 commercial demonstration projects by 2015
  - “A concerted effort to properly address financial, economic, technological, legal, institutional, and social barriers will enable CCS…”
- Must launch “at scale” CCS projects now, with urgency, to reach DOE 2020 deployment target
### DOE Large Scale CCS Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Location</th>
<th>Capture Rate (tonnes/yr)</th>
<th>Repository</th>
<th>Start Date</th>
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<tbody>
<tr>
<td><strong>Oxy-Combustion</strong></td>
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<tr>
<td>FutureGen 2.0</td>
<td>Meredosia, IL</td>
<td>1,150,000</td>
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<td>Archer Daniels Midland</td>
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- Foundation for technology competition for new, retrofit and repowering scenarios
- Puts 1st generation commercial CCS technology in place by 2020
Oxy-Coal Combustion

- Nitrogen removed from the process
- Flue gas contains carbon dioxide and water (plus remnant emissions)
- Environmental control equipment cleans remnant emissions with remainder removed by CPU

Near Zero Emission Plant (NZEP) Design

- Oxy combustion provides integrated emissions control for entire flue gas stream
- Oxy-Coal emissions predicted to be lower by several orders of magnitude
FutureGen 2.0
Oxycombustion Carbon Capture Plant

Current FG2.0 Power Block Configuration

- Pulverizers
- Coal
- Boiler
- Steam; 2400psi, 1000F/1000F
- Burners
- Recycle Heater
- PJFF
- Gas Cooler
- ID Fan
- WFGD
- DCCPS
- Gas Htr
- CPU
- Sorbent for SO₃
- To Storage
- Recycle Damper
- Primary Fan
- Air Intake
- Cool Recycle Process

Oxycombustion Carbon Capture Plant
B&W Oxy-Coal Combustion R&D Summary

Plant size (MWe)

2003: SBS I – Pilot tests
2005: Eng Studies (25-790 MWe)
2007: 30 MWth CEDF Demo
2009: Integration Study
2011: 650 MWeg Project FutureGen 2.0
2013: 700 MWeg Reference
2015: 200 MWe Project FutureGen 2.0

B&W Oxy-Coal Combustion R&D Summary
Clean Environment Development Facility (CEDF)

**Original Facility**
- Large scale pilot plant for combustion and emission testing (30 MWth)
- Low NOx burner development and HAPS testing

Commissioned in 1994

**Oxy-Combustion Facility**
- Tests conducted during Fall 2007 and Spring 2008
- Three fuels: bituminous, sub-bituminous and lignite
- “Wet” burner tests conducted in Summer 2008

2007 thru 2008

**Accomplishments:**
- Combustion, Burner and Pulverizer Operation
- Boiler heat transfer characteristics
- Oxygen injection system
- Controls - air/oxygen, combustion, safety/interlocks
- Low NOx operation w/o SCR
- FGD and ESP operating performance
- Flue gas moisture removal
- Forced oxidation of wet FGD slurry
- Ability to meet flue gas spec to CPU

Today

**Accomplishments:**
- Developed XCL, XCL –HV and 4S coal burners
- Confirmed HAPS formation and fate
- Developed AireJet burner; first burner fully CFD developed and designed: without small scale pilot plant testing

2007 thru 2008
**Oxy-Coal Reference Plant**

- **Coal**: PRB, 8400 Btu/lb
- **Steam**: 3500 psi, 1100F/1100F
- **Gross Output**: 703.6 MWe
- **Net Output**: 518 MWe
- **Heat Rate**: 10,823 Btu/kWh
- **Net Efficiency**: 31.5%
- **LCOE Range**: $92 to $112

* Spring 2011 completion of economic analysis
Benefits of Oxy-Coal Combustion

• DOE-NETL studies show oxy-combustion has the potential to be the highest efficiency and lowest cost CO$_2$ capture technology for coal fired plants*

• Completes DOE programmatic goals of demonstrating future clean coal technologies

• Near Zero Emissions of criteria air pollutants (NZEP)

• >90% CO$_2$ capture at pipeline quality and purity specifications

• U.S.-developed technology for CO$_2$ Capture from coal combustion

• Low technology risk – plant components are primarily conventional equipment modified for operation in the oxy-mode. An oxy-plant will look and operate like a conventional power plant.

• B&W and Air Liquide America have led oxy-combustion development since 2001- both are experienced technology providers with a long history of successful large scale project execution

DOE/NETL 2007-1281 Rev.1, August 2007 “Cost and Performance Baseline for Fossil Energy Plants”
Future Gen 2.0

200 MWe Oxycombustion
Project Structure

Project Organizational Structure

FutureGen Alliance Confidential Information

OxyCombustion Repowering

Cooperation & Technology Agreement

CO₂ Pipeline & Storage Hub

Project Oversight

Project Management & Execution

www.FutureGenAlliance.org
Meredosia Power Station
- Meredosia, IL: Owned/operated by AER
- 3-coal fired units (2 retired)
- Unit 4, 200 MWe oil-fired built in 1975
- 160Bar / 540C / 540C

Project Structure
- Capture – Ameren Energy Resources (AER), teamed with B&W
- Transport & Storage – FutureGen Industrial Alliance
- Repower Unit 4 steam turbine
- Purpose-built Oxy-PC boiler
- Coal variations to be evaluated
- $1.3B Investment w/ US-DOE

Project Timeline
- Project awarded Sept. 29, 2010
- FEED and NEPA complete 2012
- “Ready to test,” early 2016
- Transport/Storage solicitation in progress
FutureGen 2.0 Clean Coal Plant
FutureGen 2.0 Site Plan

Existing Turbine and Boiler Area

Existing Boiler Unit 4

New Boiler Area

ASU

CPU
Project Structure

Alliance’s International Participation

- Alpha Natural Resources
- CONSOL Energy
- CATERPILLAR
- Exelon
- Peabody
- Anglo American
- BHP Billiton
- E.ON
- Rio Tinto Energy America

(Intention Announced)
Project Structure

Alliance Background

• Formed in 2005 as a non-profit organization with a mission of advancing clean coal technology in partnership with the U.S. Department of Energy

• Non-profit consortium of coal production companies, coal trading companies, mining equipment suppliers and coal-fueled utilities

• Alliance is expanding its membership

• Balance of the funding is derived from:
  – U.S. Department of Energy
  – Power purchase agreement with associated CO₂ services agreement
  – Modest Financing
Potential CO₂ Storage Resource

Enabling Regulatory Environment

• Clean Coal Portfolio Standard Law
• Clean Coal FutureGen for Illinois Act
• NEPA/EIS experience and success by FutureGen Alliance
• State of Illinois Coal Development and Research Programs
• Subsurface rights defined, significant resource development history

Meredosia

CO₂ Storage Potential of Deep Saline Formations in the Illinois Basin

Meredosia

Mt. Simon Sandstone

Metric tons per km²

High: 1,700,000
Low: 140,000

Total Potential:
29 to 117 billion metric tons
**Project Description**

**CO₂ Pipeline and Storage Hub**

- Develop a deep saline regional storage facility that would sequester CO₂ from Meredosia and other sources

- The concept of CO₂ hubs is not new
  - Included is Australian CCS Roadmap
  - Common in European discussions
  - CO₂ pipeline networks used in enhanced oil recovery applications

- Multiple major CO₂ sources within 100+ miles of Meredosia
Post-Combustion Capture
Post Combustion Capture (PCC) for CO₂

- Partial capture solutions considered essential for creating options for existing fleet transition to reduced CO₂ emissions
- RSAT solvent tests at National Carbon Capture Center
- Advanced solid sorbents and solvents program

B&W Reference Plant

Tenaska, Trailblazer Project

Advanced Capture
- NCCC is the DOE supported post combustion capture test center with multiple test units using flue gas from operating boiler at SoCo Plant Gaston
- B&W won competition to be first to test in Pilot Solvent Test Unit, ~10 tpd pilot plant that is full “replica” of deployable system – the key next step
- Testing to be completed on OptiCap solvent and run for ~90 days to test durability and determine operating characteristics in power plant environment
Our Commitment to CCS Innovation Remains Strong

**Oxy-Combustion Innovations**
- Target LCOE increase to <35%
- Larger single train ASU
- Advanced USCPC for efficiency to ~39% with CCS

**Oxy-Combustion Adaptive Plant**
- Make LOX off-peak
- Higher output on-peak
- Reduced CAPEX

**Chemical Solvent Evolution**
- Reduce energy use 20%
- Optimized and new formulas
- Solvent “enhancers” (e.g., enzymes)
- Market-ready 2015?

**Chemical and Physical Sorbents**
- Reduce energy use >>20%?
- Enhanced natural materials
- Man-made molecules
- Market-ready 2020?
Thank You